Modelling the Housing Market and Housing Satisfaction in Urban China

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MODELLING THE HOUSING MARKET AND HOUSING SATISFACTION IN URBAN CHINA

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Abstract

The past three decades have witnessed the rapid development of the Chinese housing market[1], which is considered as a barometer of and an extremely crucial component of the whole Chinese economic system. Although some important findings have been obtained by previous research, many conclusions have been controversial and a comprehensive understanding of the mechanism and behaviour of the Chinese housing system is a worthwhile endeavour.

The existing studies about the Chinese housing market are mostly confined to qualitative analysis, lacking the support of a theoretical basis and empirical research. This thesis aims to employ more recent econometrical methodologies, from both theoretical and empirical perspectives, to systematically analyse several prevalent issues of the Chinese housing market. More specifically, this thesis is going to explore the main determinants of house prices, the convergence and ripple effects of regional house prices, and the interactive relationship between housing conditions and individual's subjective well-being.

Some empirical findings can be drawn from this thesis: 1) by using the system GMM dynamic panel data models, the results indicate that Chinese house prices are mainly affected by factors related to government policies and speculative demand rather than the urbanization process, which is understandable in a non-fully market-oriented status quo; 2) there is evidence of very limited convergence of regional house prices by employing unit root tests, σ-convergence and β-convergence approaches; however, the alternative methods, such as panel regression models, Engle-Granger/Johansen cointegration tests and Granger Causality tests, imply that house prices can ripple out from some core cities to other cities; 3) the results of the Ordered Probit Models suggest that the housing conditions in urban areas play a significant role in peoples' subjective well-being in respect of housing satisfaction and overall happiness; additionally, the effects of housing factors impact on different groups of residents in different ways.

Due to the limitations of data sources in the early days, this thesis is the first to combine such a wide panel data series, on both the time dimension and geographic dimension, to study the Chinese Housing Market. Also, when analysing the convergence and ripple effects models,

[1] 'The Chinese housing market' in this thesis refers to the housing market in urban China, because the rural area of China still implement the homestead system, which is completely different to the common concept of 'housing market' system across the world. Generally, the homestead system in rural China aims to allocate homestead land to rural individuals by the village committees based on the average principal.

this thesis transfers the original link indexes used by previous scholars into modified constant growth indexes, which improves the efficiency of empirical models to a greater extent. In addition, approaches using the system GMM method, σ- and β-convergence analysis, Engle-Granger/Johansen cointegration tests and Granger Causality tests are first introduced into the study of the Chinese housing market, generally achieving good results especially in the determinants of house prices and the ripple effects of regional house prices. Moreover, except for the commonly used method of the Ordered Probit Model for the questionnaire survey research, this thesis produces the predicted value of housing satisfaction by using two-stage estimations, to investigate the effects of housing conditions and housing satisfaction on people's overall happiness. Meanwhile, the approach of 'money equivalent effects' is also a new perspective in detecting the effects of housing conditions on overall happiness.

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Glossary

[1] **The reform and opening up**: this policy was carried out by Chairman Deng in 1978, which marked the date that the Chinese economy started to transform from the centrally planned economy to the market economy.

[2] **Shi Ye Dan Wei**: quasi-government organizations.

[3] **Zhu Fang Gong Ji Jin**: the Housing Provident Fund program.

[4] **Quanqian**: refers to the property developers using many different ways to get financing from the market, especially the stock market and bond financing.

[5] **Quandi**: buying and holding land in hand as much as possible.

[6] **Wudi**: enterprises hold the land without selling or constructing any buildings

[7] **Wupan**: property hoarding, means enterprises delaying selling their dwellings in order to get more profits from house price increases.

[8] **NBSC**: National Bureau of Statistics of China.

[9] **Tube-shaped apartments**: a typical housing style in China, which is a product of the Chinese state-owned enterprises welfare housing system in the 1970s and 1980s. These buildings are dormitories with a long corridor, shared toilets & kitchens, and the same size individual rooms, usually less than 20 m^2 for each room.

[10] **An Ju Gong Cheng**: the largest affordable/low-renting housing project supported by the governments.

[11] **'90-70' Policy**: in 2006, the central government issued a declaration that real estate developers are obligated to allocate 70% of the total area in each of their new housing projects to 'affordable housing', i.e., smaller than 90 m^2 per unit.

[12] **Diwang**: the highest records of land transfer fees.

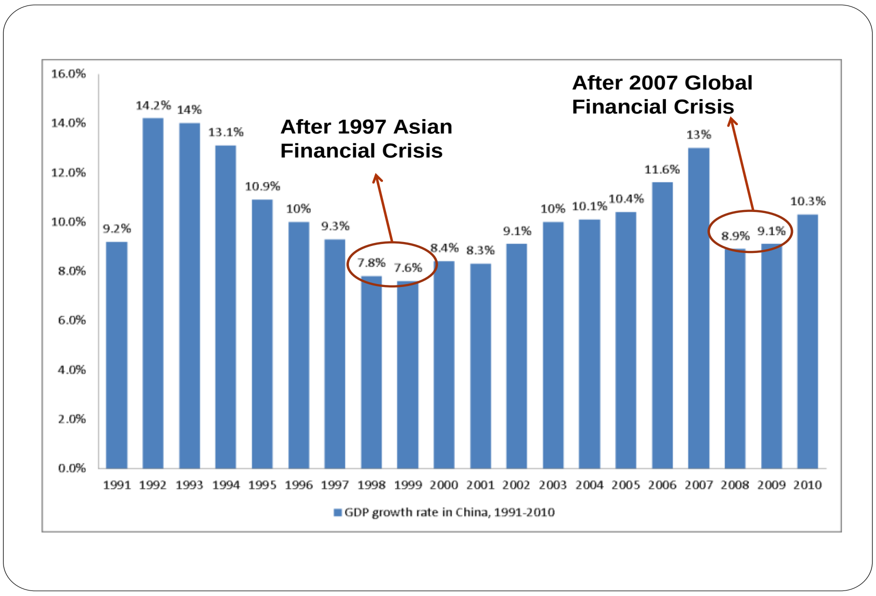
[13] **Wenzhou Real Estate Corporation**: speculators from Wenzhou, a rich and developed area in Zhejiang province, that build up groups to acquire buildings for speculation in big cities, such as Beijing and Shanghai.

[14] **Hukou**: a unique Household Registration System in China with two types: official migration with Hukou transfer (or permanent migration), and unofficial migration without Hukou transfer (or temporary migration).

Chapter 1—Introduction

1.1 Research Motivations and Contributions

As we know, China has become one of the fastest developing countries in the world. Even during the Asian and the Global Financial Crises, the Chinese economy has still maintained a very high-speed of growth. As we can see from Figure 1.1, China's GDP growth rates have only dropped slightly after the 1997 Asian Financial Crisis and 2007 Global Financial Crisis. Even during the crisis, the growth rates have stayed around 8%, which is still very impressive. Afterwards, China's economy has recovered very quickly from the financial crisis.



(Data Source: National Bureau of Statistics of China http://www.stats.gov.cn/)

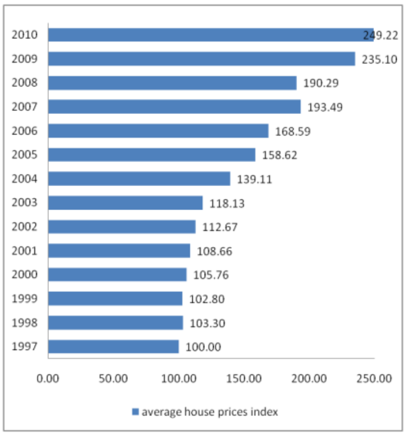
Figure 1.1: GDP Growth Rate of China: 1991-2010

The housing market relates to a significant industry for the whole economic system and has always been a barometer of the economy. Since the welfare housing system[2] has been gradually phased out in the 1990s, the Chinese housing market has been through a rapid development over last two decades. In recent years, the fast urbanization has provided another favourable opportunity for the real estate market. Meanwhile, benefitting from land policy, financial support and local government policies, the high rate of return of the housing industry has attracted huge amounts of investments, to the extent that the Chinese housing market has sustained an increasing growth trend over recent times.

[2] Under the welfare housing system, all land and housing resources were entirely owned, built and delivered by the state or state agents, such as local public entities and work units.

Real estate wealth has become one of the major factors promoting economic growth in China. It reflects not only the tendency for economic development but also the speed of economic development. Since the reform and opening-up[3], marked changes have occurred within the Chinese housing market and the behaviour of the housing market in China has had a significant impact on the aggregate economy. Housing accounts for a significant proportion of the wealth of the personal sector[4]. Over the last 30 years in China, both the super-fast economic growth and the rapid increase of personal disposable income have stimulated the demand for owner-occupied dwellings, and thereby there has been a dramatic increase in house prices and house purchases. During the global financial crisis periods, most countries' housing markets have been through an unprecedented rough time; while the Chinese housing market has sustained growth rather than a depression, and Chinese house prices have kept an upward trend since the reform and opening-up in 1978 (see Figure 1.2).

year	average house price (yuan/m^2)	average house price index (1997=100)
1997	1997	100.00
1998	2063	103.30
1999	2053	102.80
2000	2112	105.76
2001	2170	108.66
2002	2250	112.67
2003	2359	118.13
2004	2778	139.11
2005	3168	158.62
2006	3367	168.59
2007	3864	193.49
2008	3800	190.29
2009	4695	235.10
2010	4977	249.22



(Data source: National Bureau of Statistics of China http://www.stats.gov.cn/)

Figure 1.2: Chinese Housing Price Index: 1997-2010

In order to control the excessive growth in house prices, Chinese governments have implemented many kinds of policies to control the housing market. But, the results are not as good as was perhaps expected. Therefore, there are some issues catching our attention and curiosity: Why can the Chinese housing market keep booming? What forces drive up Chinese house prices even during the global depression and despite the governments' pressure? And, is there convergence between regional house prices in China? Furthermore, do the housing conditions affect individual's subjective well-being and thus will the housing boom have contributed to that too?

[3] The reform and opening-up policy was carried out by Chairman Deng in 1978, which marked that Chinese economy started to transform from central planning economy to market economy.
[4] A similar situation exists in the UK (Holly and Jones, 1997) and US (Poterba, 1991).

The existing studies about the Chinese housing market are mostly confined to a qualitative analysis, lacking the support of any theoretical basis and empirical research. With a comprehensive review of the literature on the Chinese housing market, this thesis aims to systematically investigate the fluctuations and determinants of Chinese house prices by qualitative investigation and quantitative examination. Furthermore, in order to detect how regional house prices interact with each other, this thesis is going to examine the varying patterns of regional house prices through the convergence and ripple effects between them. In addition, due to the importance of housing for Chinese people, it is also worth studying the relationship between housing conditions and subjective wellbeing in urban China.

Based on the research findings of western developed countries, whist accounting for China's practical situation, this thesis builds a Chinese house price model by using updated Chinese data. Figure 1.3 shows the regions of China (31 provinces in China excluding Hong Kong, Macao and Taiwan). More specifically, the panel data across 30 provinces over the period 1999 to 2009 will be used to examine the factors determining real estate prices. The quarterly house price indices for 35 major cities over 1998Q1 to 2010Q4 will be used to detect the convergence and ripple effects of regional house prices. Finally, the 2006 Chinese General Social Survey data covering thousands of urban householders will be applied to study the individual subjective wellbeing.

Figure 1.3: The Map of China

A number of innovative methodologies will be developed in this thesis. For instance, on the determinants of Chinese house prices, the previous research is limited to the standard estimation approaches, such as OLS or VAR. While this thesis constructs a GMM dynamic panel data model, targets the impact factors determining real estate prices, and finds out the way that these factors affect house prices. Meanwhile, the robustness checks will verify our findings by using different variables, or different estimation approaches. The study of convergence and ripple effects of regional house prices will comprehensively compare the results of several methods, such as unit root tests, σ-/β-convergence analysis, panel regression models, Engle-Granger/Johansen cointegration tests and Granger causality tests. While the commonly used method for the survey research, the ordered probit model, is employed to discover the interactive relationship between housing and people's life satisfaction. Furthermore, this thesis will explore their distinctive effects within different groups as well, by setting up divisions based on age and income.

Throughout this thesis, my findings suggest that Chinese house prices are mainly affected by government policies, such as monetary policy and land policy, rather than by market economy factors. That reflects the non-fully market-oriented nature of the Chinese housing market. Although the house prices have been rising all over the country, there is very limited evidence of convergence between regional house prices; however, to some extent, the real estate prices of several major cities, such as Beijing, Shanghai and Shenzhen, 'ripple out' to other regions. Meanwhile, my results show that the housing-related conditions play a significant role in the people's life satisfaction, with different degrees of effects on different groups.

My research also contributes to the literature by revealing the nature of the Chinese housing market and supplies prospective information for potential real estate investors which may help prevent a further housing market bubble forming and even a financial crisis. To some extent, my results also imply some policy recommendations for the administration particularly with respect to the regulation of the Chinese real estate market. In short, research on the Chinese housing market, of which this is a part, plays a significant role in stabilizing the national economy, promoting the healthy and steady development of the Chinese housing market, and improving citizens' welfare.

1.2 Research Framework and Structure

The overall framework of my research is shown in Figure 1.4. Firstly, this thesis will introduce the development of the Chinese housing market by focusing on the practical situation of Chinese real estate development in recent years, especially, summarising Chinese housing reform and the associated policies. This thesis includes three empirical chapters in total. The first empirical part is to construct the econometric models to quantitatively investigate the determinants of the Chinese housing market. Afterwards, the empirical analysis of house price models will focus on the convergence and ripple effects of regional house prices in China. Then, the empirical work will include the study between housing and life satisfaction in urban China as well. Finally, the thesis will conclude the empirical results, and give some policy implications and suggestions on the Chinese housing market.

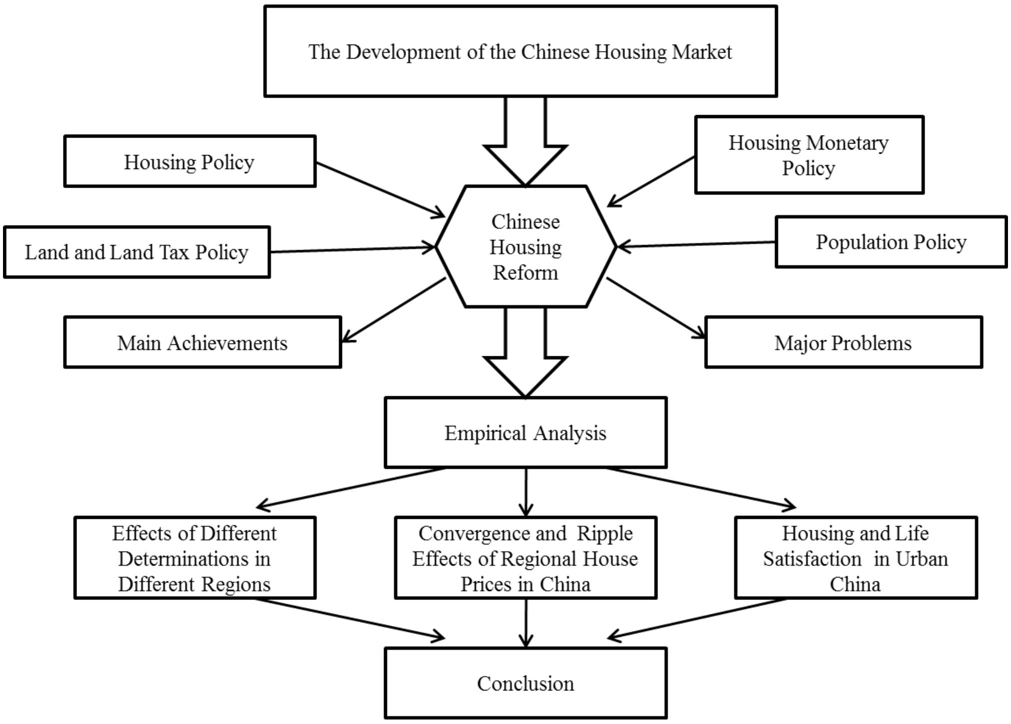


Figure 1.4: The Research Framework

This thesis will adopt the integrated method of qualitative study and quantitative research to systematically analyse the Chinese housing market. Overall, my research can be divided into six chapters:

Chapter 1 is an ‘Introduction’, including my movivations for doing this research and emphasising the original contributions, the research framework and also the structure.

Chapter 2 is ‘Background to the Chinese Housing Market’, which provides an essential overview of the major issues regarding the Chinese housing market. This chapter elaborates on the Chinese housing reform with a focus on relevant policies, such as housing policy, monetary policy, land policy and population policy. This chapter also concludes with the main achievements of the Chinese housing reform, and the major problems of the Chinese housing market.

The three empirical chapters are ‘Chapter 3—Empirical Analysis of Determinants of China’s Housing Market’, ‘Chapter 4—Testing the Convergence and Ripple Effects of Regional House Prices in China’, and ‘Chapter 5—Housing and Life Satisfaction in Urban China’ respectively. Empricial chapters have a mostly identical structure with six sections, including ‘Introduction’, ‘Literature Review’, ‘Methodology’, ‘Data Source and Description’, ‘Empricial Results’ and ‘Conclusion’.

Chapter 6 is the ‘Conclusion’, which summarises my research and the empirical findings, gives the practical policy implications and suggestions for the Chinese authorities, and also implies the possible research orientations in the future.

To sum up, this thesis raises some new perspectives and different findings on the Chinese housing market in many areas, such as the research framework and the research methodology. My research summarises research achievements about the Chinese housing market, and combines the theoretical and empirical studies by adopting approaches previously used for the western developed countries. This thesis improves upon the existing mature models of house prices by considering China’s actual conditions, and uses updated Chinese data to run the empirical tests. Finally, my findings give conclusions and policy implications. The theories about the real estate market have been in a sustained development process; my study extends the research of the Chinese housing market, deepens the empirical research, and widens the range of applications.

Chapter 2—Background to the Chinese Housing Market

2.1 Introduction

This chapter describes the background of the Chinese housing market[5]. Firstly, we introduce the development stages of the Chinese housing market since 1978 and explore the different features of the housing market at different stages. This can be divided into four main steps: the gestation period from 1978 to 1988, the fledging stage from 1990 to 1995, the growth phase from 1998 to 2002, and the adjustment stage since 2002. This study will concentrate on the latest two stages since the implementation of a brand new housing system in 1998.

Then, we summarise the relevant policy changes during this period of Chinese housing reform, including housing policy, land policy, land tax policy, housing monetary policy[6] and population policy. These policies have had profound influences on the real estate market through the whole development process. As a result of the rapid development of the Chinese housing reform, a number of achievements have been made, such as the diversification of housing types, a higher home ownership ratio, more housing space per capita, and the quick growth in housing demand and housing supply.

However, the remarkable achievements have been accompanied by prominent conflicts in the Chinese housing market as well. The major problems include the huge housing inequities for different householders, the lack of sufficient affordable housing supply, and a classical principal-agent problem. At the end of this chapter, we will summarise the Chinese housing market from a panoramic point of view.

2.2 Overview of the Chinese Housing Market Development

The housing market is a significant industry for the whole economic system in China and has always been a barometer of the economy. Before the reform and opening-up, the Chinese housing system was a component of social welfare and was provided mostly for free by government institutions and state-owned enterprises, also known as work units. Since the reform and opening-up, against the background of rapid economic development in China, the real estate market has developed quickly. Based on the summary of previous studies, as a whole, there are four stages to the housing market development in China over recent times

[5] This chapter has been presented in the *'6th Annual International Symposium on Economic Theory, Policy and Applications'*.
[6] 'Housing monetary policy' in this thesis refers to monetary policy particularly on housing.

(Li and Yi, 2007; Deng, Shen and Wang, 2011).

The first stage (1978-1988) is the gestation period. Some state owned enterprises built welfare rooms for their staff, and meanwhile the first real estate companies started up. In this period, the citizens basically lived in the workers' dormitories; therefore, most people did not have their own houses and only small numbers of individuals had a demand for housing in relatively developed parts of China. In the meantime, housing reform experiments were conducted in several selected cities by means of selling public housing at cost price and the gradual raising of public housing rent. The experiments of this stage were to test the feasibility of public housing reforms and devolve the decision making from central government to the local government and enterprises; in particular, the State Council issued 'the Implementation Plan for Gradual Housing System Reform in Cities and Towns' on a nationwide basis (Wang and Murie, 2000).

In the second stage (1990-1995), the real estate industry started to grow, and there were some business activities related to land transactions. After the Chairman Deng's speech about further reform and opening-up[7], the Chinese economy entered upon a new sharply expanding phase. The first property boom appeared between 1992 and 1993. In 1994, the Chinese central authority promulgated 'The Decision on Deepening the Urban Housing Reform', which established a comprehensive framework for housing reform and further spelt out the details in the next stage (Huang 2004). During this stage, two distinct systems of housing provision were established: (i) 'economic and suitable housing' provided by local authorities and enterprises, and (ii) 'ordinary commodity housing' provided by the market. However, work units and enterprises proceeded to dominate the housing provision. As such, this stage can be termed the 'double-track stage' (Li and Yi, 2007).

Against this background, housing investment increased rapidly and large quantities of real estate companies were set up, such as the Chinese first and largest real estate company, Vanke. But because of these companies' overdevelopment and speculative operations, it led to some problems for the housing market in many areas, such as a real estate bubbles and numerous uncompleted edifices, especially in Hainan province (Han, 1998; Wu, 2003; Wu, Reed and Robinson, 2006).

The third stage (1998-2002) was a quick development stage. According to the State Council

[7] This speech was announced in 1992 when Chairman Deng made his Southern Tour in Shenzhen Special Economic Zone.

announcement [8] in 1997, the welfare-room system changed radically. In 1998, another milestone of the housing reform occurred when the central government announced 'A Notification of the Urban Housing System and Accelerating Housing Construction', which means an end to the welfare allocation of urban housing. The role of work units was redefined in the housing system. The end of welfare housing allocation now not only means ending provision of rental public housing to state-owned enterprise workers but also to government and quasi-government authorities, the latter being known as '*Shi Ye Dan Wei*' (Li and Yi, 2007).

The housing market showed a demand for more space and the material standard of living has been raised to a great extent. Specifically, the bigger house size, more number of rooms, and having bathroom or living room will most likely increase subjective well-beings. Because it was the early stage of the housing market and the requirement for sustaining domestic demand, the housing policies were not strictly controlled and lowered the standards of housing quality. This new market-based housing system also has particularly Chinese characteristics (Deng, Shen and Wang, 2011). For instance, even though work units no longer built apartments directly for their workers, they still played an important part in their employees' housing consumption, either through cash-based housing subsidies or through their contribution to the Housing Provident Fund (*Zhu Fang Gong Ji Jin*) program. Therefore, there were various problems with this situation, especially the 'land rent-seeking' problem. Even worse, a number of property developers speculated on land transactions and the land market was very disorderly. In order to limit these activities, the State Council announced some special measures to regulate and prevent problems occurring.

The fourth stage (2002-now) is the housing industry adjustment period. In 2002, the Ministry of Land and Resources issued the competitive bidding, auction and listing-for-sale transfer policy for the right to use state-owned land as profit-oriented land. Since then, the development of the land market has become standardized. The implementation of the policy reduced the possibility of 'rent-seeking' and thereby those enterprises relying on land speculation lost their viability, while those real estate enterprises, with powerful financial support and rich experience in developing the housing market, started a large-scale expansion throughout the nation. The new real estate investment boom has been triggered by the vigorous expansion of real estate enterprises and the sustained market demand. Since 2002,

[8] This announcement was carried out to speed up and reform further the construction of the housing system.(3rd July,1997)

there have been some debates about the housing market bubbles. As a consequence, the Central Bank issued ‘No. 121’ document, stipulating that the real estate projects without completed procedures and adequate capital shall not get grant loans, shall not use the endowment bank loans and real estate projects shall not get a mortgage until the completion of the main construction. This led to tremendous pressures for real estate companies, which depended on bank loan support. Nonetheless, the government has not stopped trying to control the housing market. More stringent policies created pressure and challenges for some companies, who started to withdraw from the housing industry.

In this context, the State Council issued ‘No. 18’[9] document on September 2003, which was the first time publicly that the real estate industry had been accepted as a pillar of the national economy and that it was recognised that the housing market required sustainable and controlled development. ‘No. 18’ document not only addressed the problems of the housing market to some extent, but also worked out some industrial polices, ‘supporting the real estate enterprises who had a good reputation and brand advantage to form lots of competitive and large enterprises and enterprise groups through mergers, takeovers and restructuring’ (‘No. 18’ document). Therefore, under the guidelines of these policies, a property boom has occurred in some areas of China since 2004 and the house prices of the Yangtze River Delta, including Shanghai and Hangzhou, grew by double-digit figures. In the second half of 2004, the fear of a real estate property bubble arose again. Since March 2005, the State Council, Ministry of Construction and other government departments not only implemented policies to stabilize house prices, but also issued policies to enhance the management of real estate taxation. The biggest difference in this adjustment was laying stress on the demand side of the housing market, especially to inhibit the demand for investment and speculative real estate. A series of policies for accessing housing led to a wait of more than six months or longer, but also made some companies better off because of the industrial regulation and integration. Meanwhile, some industry giants have taken shape, such as the Vanke and Shoukai[10] enterprise groups.

During the period of great prosperity, Chinese house prices have been rising very quickly, and have only dropped slightly after the 1997 Asian and 2007 Global Financial Crises. As a result, some latent issues have arisen in the Chinese housing market, that are typical and yet totally different from other countries’. We will discuss these problems later in this chapter. After

[9] ‘An Announcement on Promoting Persistent and Healthy Development of the Real Estate Market’. The State Council. [2003] No.18

[10] Shoukai Enterprise Groups is the biggest real estate company in Beijing, who participated the construction of the National Indoor Stadium and Olympic Village.

three decades of reform, the Chinese housing market has developed a complicated construction system. One key complication in the Chinese housing market is that it is not fully-marketized in the real sense. The central and local governments' macro regulation and control still plays an important role in the housing market. More specifically, the government is a monopolist in the ownership of land. Additionally, the government adjusts the house prices through political and monetary policies to affect the investors and consumers’ market behavior. Furthermore, based on different levels of development in different areas, the situation of the housing markets are widely different.

In addition, a number of vague market manipulations occur, such as ‘*Quanqian*’ and ‘*Quandi*’, which have become very popular in the Chinese housing market since 2007. ‘*Quanqian*’ refers to the property developers using many different ways to get financing from the market, especially the stock market and bond financing. Just in the year of 2007, 38 real estate enterprises increased or announced an increase in their issues of stocks and bonds, involving 102.43 billion yuan (13.47 billion US$[11]). After real estate developers captured enough funds, ‘*Quandi*’, meaning the buying and holding of land as much as possible has become their next aim. To some extent, this behaviour explains the reasons for the Chinese stock market boom in 2007. Additionally, property developers not only have ‘*Quanqian*’ and ‘*Quandi*’ but also conduct ‘*Wudi*’ and ‘*Wupan*’. ‘*Wudi*’ is when enterprises hold the land without selling or constructing any buildings; ‘*Wupan*’, also known as property hoarding, means enterprises delay selling their dwellings in order to get more profits from house price increases. More specifically, Li Dong (2010) illustrated that real estate developers lie to consumers that the supply of their apartments fails to meet the demand, claiming unsold housing as sold ones. They drive up house prices through this strategy.

The development of the economy and the increase in national income fundamentally contributes to promoting sustainable and rapid growth of Chinese house prices, but there are still other specific factors, different to other developed countries’ situation, which artificially increase house prices. The problem of population plays an important negative role in the housing market. There are 1.3 billion people in China and the land possession per capita is less than 1/3 of international average levels[12]. What’s worse, the population has been sustainably growing since the Founding of the People’s Republic of China in 1949. According to the China Statistical Yearbook, the population was only 0.54 billion in 1949 and

[11] From the NBSC, the average exchange rate in 2007 is 7.6040 yuan/US$.
[12] Data source from China Statistical Yearbook.

grew to nearly 1.3 billion in 2004; while by 2009, the population reached 1.33474 billion. China's total population has increased by 2.464 times during the last six decades. In face of the heavy demand for houses, the structural imbalance of supply and demand in the domestic housing market is more and more serious. More specifically, the supply is far from meeting the demand, which motivates the price increases. For 'Rational-Economic Man', the profits' proportion of economically affordable houses is limited to within 3%, and real estate developers prefer to supply more high-grade apartments for the sake of much higher profits; thus, the economically affordable dwellings for middle and low income groups fall severely short of demand.

According to Sohu Focus's editorial[13], the percentage profits in the Chinese housing market are as high as 30% to 50%, the profit ratios of some projects even reach up to 100%-200%; but for the developed countries, the profit ratio is lower than 10%. This situation stimulates domestic and foreign property speculation in the Chinese housing and stock markets. The data form NBSC demonstrates that foreign 'hot money' has been getting into the Chinese housing market and has reached two peaks in 1997-1998 and 2006-2007. This speculation contributes to the property bubble in the whole market, which is likely to lead to a series of contagion effects. On the other hand, the real estate industry, with its high profits, now has an important position in the whole national economy in China. The percentage of real estate investment in total fixed asset investment is as high as 70% to 80%, which indicates the importance of the real estate industry.

Due to the importance of the real estate industry, the behaviour of the authorities plays a significant role in the development of the Chinese housing market. The Chinese housing market is not completely-marketized, as it is a policy based market, the government dominating the two most important inputs—the supply of land and funds. On one side, the real estate industry promotes local economic development and the swift growth of local GDP. On the other side, the high taxes fulfil the authorities' need for fiscal revenue. Therefore, the central and local governments have been gradually revising interrelated policies, such as the land transfer policy and the real estate enterprises issuing of stock. Other than the authorities' contracts, bank loans are another dominant factor in increasing house prices.

To sum up, as a result of the imperfect market, there exist various problems in the Chinese housing market; and due to these characteristics and problems, it becomes an interesting issue

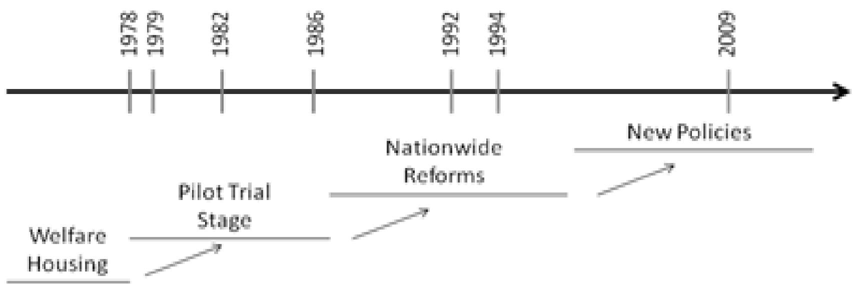
[13] Sohu Focus: http://house.focus.cn/news/2009-09-15/757349.html [Accessed 9th July 2011]

and worthy of further research into the Chinese real estate market and house prices.

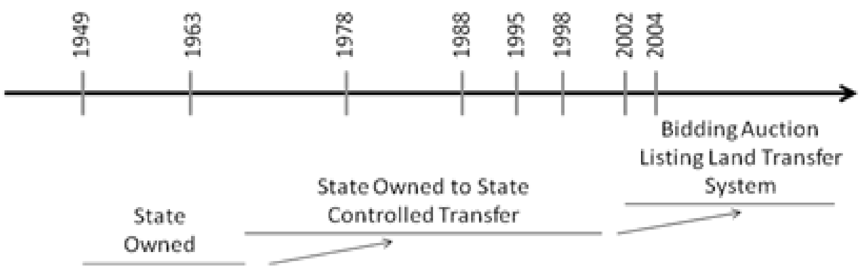
2.3 Chinese Housing Reform

Chinese housing reform has been a complex development process, including many reforms and changes of related policies, such as housing policy, land policy, land tax policy and housing monetary policy. The housing reform in China is also a profound social change, which in turn affects the relevant policymaking. Various policies impacting on the Chinese housing market have been changing and reforming over the last several decades since the founding of the New People’s Republic of China. Overall, there is a time line for the development of these policies. Figure 2.1 clearly expresses the different policies’ time lines. More detailed policy reforms will be discussed in the following parts.

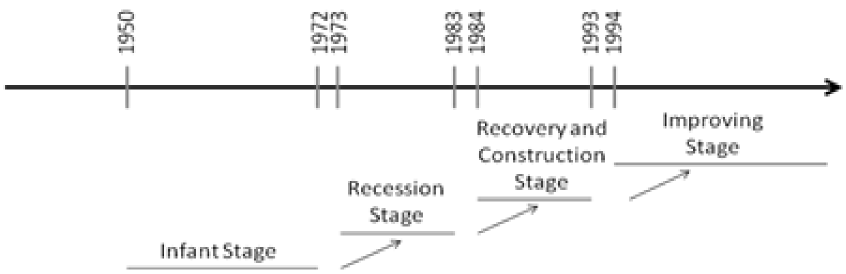
Figure 2.1: The Development Time Lines of Different Policies



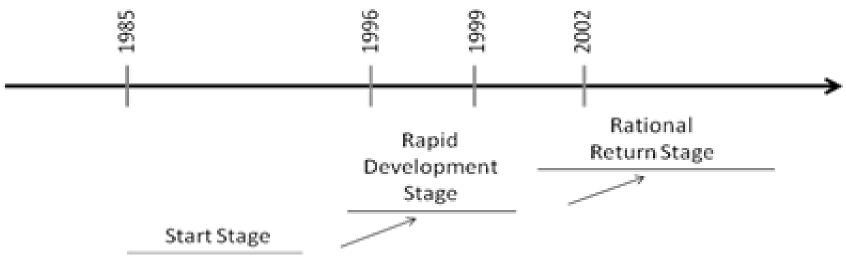
(a) Housing Policy (Source: Gao, 2010, Figure 1)



(b) Land Policy



(c) Land Tax Policy (Source: Du, 2009, Figure 3.4)



(d) Housing Loans Policy

2.3.1 The Development of Housing Policy

Before the market reform and its opening-up, the Chinese housing market was a government-funded and government-run welfare housing system, with no interest paid and no profit on land grants and land transfers. Regarding the ownership of buildings as separate from land, normally buildings could not be bought or sold privately. To put it differently, there was no normal real estate market in China, as all land and housing resources were entirely owned, built and delivered by the state or state agents, such as local public entities and work units. Public housing was divided into two types during the central planning era: directly managed housing implemented by the local government housing administration; and self-managed housing built, distributed, and managed by state-owned enterprises and institutions for their employees and families (Fan, 1999). The urban housing conditions and supply mostly relied on investments of, either the central and local governments, or the enterprises and work units whom individuals worked for.

Under this socialistic housing policy, until the early 1990s, the rent for the house in most Chinese urban families only accounted for 1%-3% of their total income, with the average rent being only 6.5% of the full cost of rent. As a result, government investment in building houses was ultimately non-recoverable (Tang, 1989). In addition, the government has perennially been burdened with the maintenance and management cost of these buildings, which resulted in tension and insufficient construction and maintenance funding (Yok-shiu, 1988; Fong, 1989). Over that era, the welfare housing system in China had experienced severe problems, including the shortages of home building (Fan, 1999); urban zoning issues (Wang and Murie, 2000); unfair distribution wherein privileged households manipulated the allocation system (Chiu, 1996); heavy burdens on government finance, and corruption in the process of distribution and allocation (Wang and Murie, 1996).

Since the market reforms and opening-up, the socialistic welfare housing approach did not appear to attain the expected goal of 'housing for all'. To establish a new market-oriented housing system, the central government started to implement new regimes and regulations to marketize the transferring, leasing and mortgaging of real estate property, including housing.

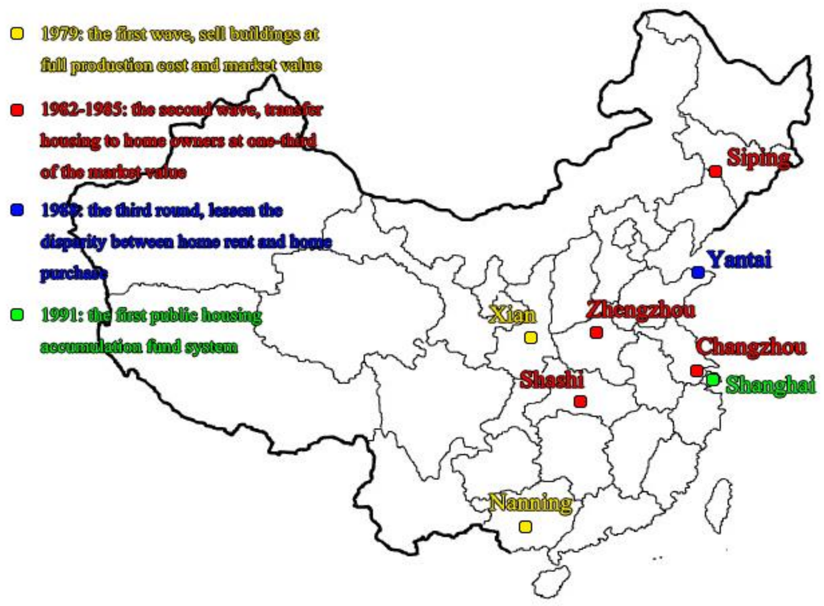
The target of Chinese housing reform was to gradually change the collectively-owned welfare housing system into the market-oriented housing regime while expanding private home ownership. Furthermore, it attempted to alleviate the financial pressure of governments at all levels, whilst resolving the housing shortage problem. Since 1978, the Chinese economic structure has been transformed from a planned economy, first to a socialist planned-commodity economy, then eventually to a socialist market economy (Gao, 2010). Consequently, the housing regime in urban areas also suffered the transition from a centrally collective, welfare-based paradigm to a more decentralized, market-oriented system (Tang *et al.*, 2006). Therefore, as an important part of the overall economic revolution, housing system changes capture transitional features as well as numerous trial-and-error patterns (Cao and Gao, 2002).

In general, it can be seen from the Figure 2.1(a) that the Chinese urban housing revolution can fall into two overall stages: the pilot trial stage from 1978 to 1991 and the real estate market development stage from 1992 to the present (Gao, 2010).

At the pilot trial stage, firstly, experimental housing reforms happened at the local levels and concentrated on increasing the rental and sales of public buildings. Then, the changes expanded to the allocation and usage of land system, in which land users rather than land owners took charge of land grade including locations and geological conditions of land (Cao and Gao, 2002). The commoditization of real estate property sector has been especially affected by deeper reform. In other words, the housing reform mainly focused on changing houses from a 'free good' to a 'subsidized good', and eventually to a 'commodity'. The house price (rental or sale price) reflects fair value of housing measured by production costs and a market profit margin (Chiu, 1996). In 1988, one of the most meaningful land amendments was settled, stating 'land use rights can be transferred in the light of law', which means the abolition of the traditional restrictions on land transfers. The Land Administration Law was amended correspondingly, although the state-owned land use rights were established as the foundation for the Chinese real estate market.

Deng Xiaoping's speeches, about the demand and direction for urban housing reform, which was an essential part of the market reform and opening-up in 1978, opened the first pilot housing reform experiment[14]. In 1979, the first wave of alterations occurred in two cities, Xi'an and Nanning, aiming at selling buildings at full production cost and market value. While before long, the amendment failed as a result of the shortage of affordable housing and the coexistence of a relatively low rental cost. Later on, during 1982 to 1985, another larger scale experiment occurred in Zhengzhou, Shashi, Siping, and Changzhou, which transferred housing to home owners at one-third of the market value, with the householders' employers and local authorities undertaking the rest of the cost. To some extent, the affordability issue was alleviated by instalment payments. However, such reforms aggravated the financial burden on employers and enterprises. As a consequence, between 1986 and 1988, the Housing Reform Steering Group, which was newly established in the central government, developed a comprehensive reform strategy. This strategy initiated a third round of the housing revolution. This stage was to lessen the disparity between home rent and home purchase via increasing not only house rental but also housing allowance in salaries, while offering housing at production cost. The successful reform in Yantai took the first step of housing reform, which swept across the nation in 1988. There were several basic and essential characteristics of reform programs through different regions: raising rental at different times and increments, offering existing housing units either by the authority agents, or by the enterprises with a discount rate, introducing housing subsidies into the salary structure to allow wage earners to afford higher rental, and founding development companies to build housing units for sale to privately-owned-and-operated individuals and work units at market value (Chiu, 1996). Drawing on the experience of Singapore, in 1991, Shanghai set up the first public housing accumulation fund system, and this practice was approved nationwide later (Chua, 1997).

[14] For more details of the trial experiment, see Tang 1989, Lee 1993, Wang and Murie 1996.

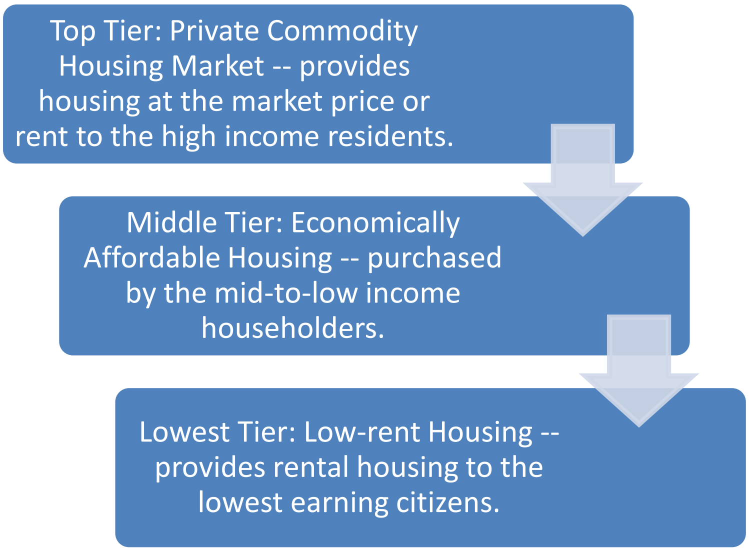


(Source: Author's summary)

Figure 2.2: The Map of Chinese Housing Reform Process

A historic turning point was in 1992 in terms of the Chinese housing market development. In the true sense, the nationwide real estate market had not been established until 1992. Under a favourable economic and political environment, the real estate industry developed rapidly afterwards. Meanwhile, many problems in the property market sector were caused by an excessive expansion. For instance, the out-of-control expansion of the housing market, the imbalanced structure of the real estate industry, the insufficiency of appropriate market regulations, and the prevalence of irregular market activities (Cao and Gao, 2002). Since 1992, the central authority has gradually changed the welfare housing distribution system into a distribution mechanism with the pecuniary allowance as part of the wage. Following the maturation and development of the Chinese housing market, an accumulation housing fund system was formally established, as well as a housing finance and insurance system.

In 1994, in order to match housing services with householder income levels, the central government carried out more changes to legislation. In accordance with the 'Decision on the Deepening of Urban Housing System Reform', the housing supply system can be diversified into three parts (Figure 2.3): (1) for high-income families, commodity houses were sold at market value; (2) mid-to-low income families were qualified to buy affordable housing at 'standard price' or 'full-cost price', defined as 'the summation of three times the average annual income of double-earner families and the estimated total housing superannuation contribution made by the work unit to the household' (Chiu, 1996); (3) while low-income families can pay off rent with further increasing 15% of average household income in 2000. In 1998, the termination of the housing allocation system was announced by the State Council. In 1999, furthermore, the Ministry of Construction clarified that current qualified residents who are willing to buy can purchase the existing public housing. In 2006, the General Office of the State Council also passed the Opinions of nine ministries and departments including the Ministry of Construction. The opinions indicated the demand to construct middle-and-small sized commodity houses for sale to low or intermediate income families. The government promulgated a series of policies and measures in response to the widening disparity between household incomes and housing demands across the urban residents. While the actual effect might be not as expected, as there is no evidence to indicate the gap has been narrowed.



(Source: Yiu, 2010)

Figure 2.3: Three-Tier Housing Policy of China

After nearly three decades of the urban housing regime reform, the Chinese housing market appears to have a general pattern: the high-income population purchase commodity houses, middle-and-low income individuals purchase affordable houses, and the demand of the lowest-income household is satisfied by low-rent houses. Even so, the Chinese housing market and regulatory system have still been going through a sustained and rapid transformation.

2.3.2 The Development of Other Relevant Policies

2.3.2.1 The Development of Land Policy

Land is not only a property asset but also a significant factor input or means of production. Its ownership and use is one major issue relating to the national economy and the peoples' livelihood. Figure 2.1(b) demonstrates the time line of the land policy development since the Founding of New China. In essence, after the establishment of the People's Republic of China in 1949, and before the market reforms in 1978, the land ownership and use rights were controlled by the state. This land regime was mainly based on two important commitments of the Constitution: 'the eventual elimination of private ownership of property and the means of production, as well as the establishment of a centrally planned economy monopolized by the state sector' (Anderson, 2010).

Since 1978, alongside transforming the centrally planned economy into a market-based economy, the ownership and user rights of land went through a gradual transition into the private sector. Table 2.1 indicates some key milestones in land system reforms after 1978. All of the key milestones play an essential role in the developing story of the Chinese land and housing market, especially the new 'Bidding Auction Listing Transferring State-owned Land Use Rights Provision' in 2002.

As Lichtenberg and Ding (2009) describe, under the current system, all land in China is owned by the state, but market forces are increasingly giving rise to a private sector. This consequence was caused by a dual system of land allocation, including some land use rights allocated via market mechanisms and other land use rights allocated via non-market approaches. The institutional reforms make it possible for the long-term lease mechanism for transferable land use rights in the land market. Particularly, urban land is owned by the nation while its use is administrated by local government authorities. These local officials lease out land use rights to the private sector with long-run leases. Historically, the rental fees of land were negotiated between the government and the private entities. Recently, however, under the pressure of market forces, the competitive auctions or tenders have become a channel for land leases.

Table 2.1: Key Milestones of Chinese Land Reforms Effecting Housing Market

Date	***Reforms***

1978	The 'household responsibility system': the cooperatives contracted land use rights to individual tenant peasant households, with the ownership retained by the commune
1983	Rural commune regime ended
1987	Land leasing system was initially introduced in Shenzhen
1988	The transfer of development rights was legitimized by the PRC's constitution
1990	The central government formally approved a ground lease system
1992	Public land leasing system spread nationwide
1994	Basic farmland protection implementation amended Tax assignment changes adopted
1995	Rules for the Implementation of the Interim Regulations of the People's Republic of China on Land Value-added Tax (Decree 6) Applying VAT to rental value of land
1996	No net loss of farmland as a result of substantial balance of agricultural land policy
1997	Circular of the Central Committee of the Communist Party of China and the General Office of the State Council on Further Strengthening Land Management and Practically Protecting Cultivated Land (Decree 11)
1998	Land Administration Law of 1998 reaffirms substantial balance policy and retrenches regulations on farmland conversion New restriction on residential housing land promulgated
1999	Circular of the General Office of the State Council on Strengthening Management of Transfer of Land and Strictly Banning Speculative Land Dealing (Decree 39)
2002	'Bidding Auction Listing Transferring State-owned Land Use Rights Provision' implemented by the Ministry of Land and Resources since 1st July 2002
2004	Circular of the Ministry of Land and Resources on Enforcement and Inspection of Carrying on the Tender to Sell the Operating Land Auction (Decree 71) The remarkable boundary of land policy, 31st August 2004, so called '8.31 major limit of land granting'. The last deadline of ending land agreement transferring. Since then, new bidding auction listing land transferring system built up
2006	'the Central Committee of Communist Party of China develops the eleventh about making the national economy and society the proposal that plans 5 years', points out the cultivated land must remain 1.8 billion acres until the end of 2010, so called '1.8 billion red line'
2009	Central authority recommends regulation of LUTRG-linkage between urban land taking and rural land giving policy, which preserves the interest of land use transfers
Since 2007	In allusion to the real estate enterprises, governments unveil fresh policies, such as the levy of land value increment tax, the supply of limited price land, and land granting via invitation to tender instead of listing & auction.

Source: Anderson, 2010, Table 1.

Under China's national land market conditions, the excessive high land leasing fees become the breeding ground for some speculation and profiteering behaviour, such as '*Quandi*' and '*Wudi*'. These behaviours refer to buying and holding land as much as possible, without developing land or constructing buildings. The developers attempt to pursue more profits waiting for the further increase of land price and house prices; meanwhile the highest records of land transfer fees, so called '*Diwang*', have been continuously broken in recent years. Table 2.2 demonstrates the '*Diwang*' of different cities across China in 2009. Furthermore, on the 15th March 2010, Beijing has three pieces of land with '*Diwang*' prices in the same single day (see Table 2.3).

Table 2.2: The 'Diwang' of different cities in 2009

City	Bid-winning Enterprise	Total Price of the Land (billion yuan)	Land Value in Terms of Per Unit Floor Age (1,000 yuan)
Beijing	Big Dragon Real Estate	5.05	29.859
Shanghai	Greentown Group	7.245	27.231
Tianjin	CITIC Group	3.6	1.434
Shenzhen	ZhaoShang HuaQiao Cheng	0.53	18.875
Guangzhou	Guangzhou Urban Construction Group	0.345	15.324
Hangzhou	Zhejiang West Real Estate Group	0.77	24.295
Ningbo	JinIie Property	0.77	8.170
Nanjing	Poly Real Estate	1.592	7.553
Suzhou	Greentown Group	3.6	28.057
Wuxi	Greentown Group	2.9	7.097
Jinan	Sinopec	0.086	17.8
Xiamen	Hengxiang Ownership	1.047	30.94
Chongqing	Cnooc Group Kowloon Storehouse	4.1	2.741
Dongguan	LongGuang Real Estate	0.703	13.088
Foshan	China Overseas Property	3.82	6.495
Hainan	China Sonangol	0.905	6.141

Data source: Sohu Focus http://house.focus.cn/ztdir/2009diwang/

Table 2.3: Three 'Diwang' in Beijing on 15th March 2010

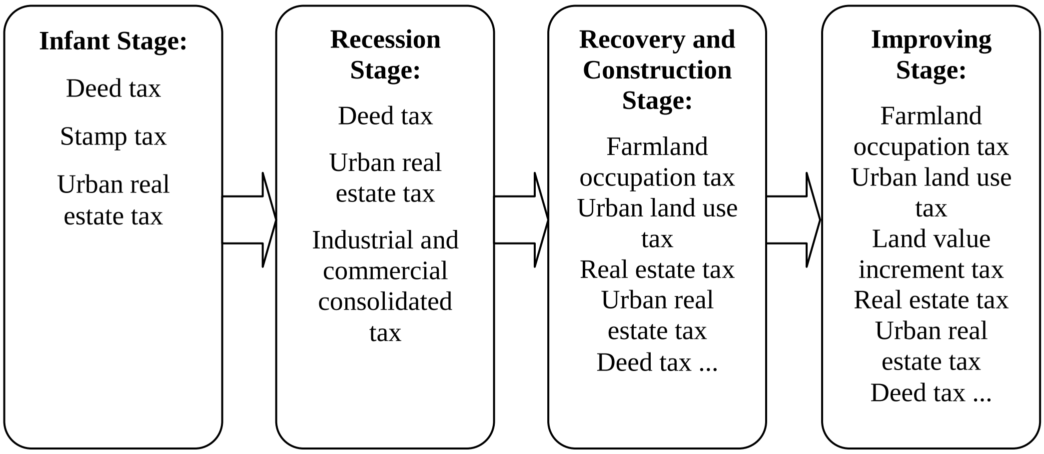
Bid-winning Enterprise	Total Price of the Land (billion yuan)	Land Value in Terms of Per Unit Floor Age (1,000 yuan)
Big Dragon Real Estate	5.05	29.859
Greentown Group	7.245	27.231
CITIC Group	3.6	1.434

Data source: Daily Economic News http://www.nbd.com.cn/

2.3.2.2 The Development of Land Tax Policy

China's real estate taxation was built up in the early 1950s. According to the development of real estate taxes, it can be classified into four stages since 1949. According to the time line of

Figure 2.1(c), Figure 2.4 shows the historical development stages of China's real estate tax system.



(Source: Du ,2009, Figure 3.4)

Figure 2.4: The development of Chinese real estate tax categories

The first stage: the infant stage (1950-1972)

At 30th January 1950, the central government announced 'Guidelines for the Implementation of National Taxes ', which started the levy of land tax, housing tax and inheritance tax; in May 1950, the Ministry of Finance promulgated 'Land Tax Provisional Regulations' and 'Housing Tax Provisional Regulations'. On 8th August 1951, the Government Administration Council published 'Provisional Regulations of Urban Real Estate Tax' to begin to collect urban real estate tax. Due to the postponement of inheritance tax, land tax and housing tax were amalgamated with real estate taxes; thus, the housing and land tax system during the initial stage of new China comprises three tax categories: real estate tax, stamp tax and deed tax.

The second stage: the recession stage (1973-1983)

During the reformation of the tax system in 1973, the central authority adjusted the incidence of real estate tax, and only collected real estate tax on the real estate management ministry, individuals, and foreign-owned enterprises. Under the background of free urban land usage, state-owned houses and tax simplification, the importance of real estate tax and deed tax declined substantially in China's tax system.

The third stage: the recovery and construction stage (1984-1993)

After reform and opening-up, in October 1984, the government reactivated the collection of real estate tax on state-owned enterprises, and also separated real estate tax into housing tax and land tax. Over 1986 to 1988, the State Council implemented three remarkable tax regulations-‘Provisional Regulations of Housing Tax’, ‘Provisional Regulations of Farm Land Occupation Tax’ and ‘Provisional Regulations of Urban Land Use Tax’-which meant the recovery of the real estate tax system.

The fourth stage: the improving state (from 1994)

The Chinese socialist market economy system was initially established during this stage. The reform of the tax system in 1994 recomposed the tax base and tax range. Furthermore, it added a new real estate tax category of land value increment tax; in October 1997 the new deed tax regulations were implemented; and moreover, on 12th December 1999, three related tax departments of the central government announced a joint intention to start collecting property transfer tax. In 2006 and 2007, governments re-modified ‘Provisional Regulations of Farm Land Occupation Tax’ and ‘Provisional Regulations of Urban Land Use Tax’ to raise the amount of tax credits.

The current Chinese real estate tax system is based on the foundation of the 1994 tax reform. There are a total of 12 tax categories relating to land, property and real estate enterprises, including urban land use tax, real estate tax, farmland occupation tax, land value increment tax, urban maintenance & construction tax, deed tax, business tax or sales tax, stamp tax, enterprise income tax, individual income tax, education surtax, and resources tax (Chang, 2007). The first six categories are straightforwardly targeted on real estate property (An and Wang, 2004; Xie, 2005). The present tax system has been designed of tax collection on three branches—holding, flowing and earning of housing property. The real estate taxes have played an impressively positive role in the comprehensive use of land resources, the rational distribution of real estate resource and the abundance of local financial income (Du, 2009).

In order to dampen down the increase of housing prices during recent years, the State Council of China has been discussing the regulation details of housing property taxes. Some large urban areas have been listed as experimental cities, such as Shanghai and Chongqing. More specifically, since 28th January 2011, housing property tax has started to be collected in these two pioneering cities. The tentative tax rate in Shanghai is 0.6%. It is between 0.5%-1.2% in Chongqing. As a new instrument to control real estate price, the housing property tax will be implemented gradually in further urban and rural areas. The levying of housing property tax has become another key milestone in the Chinese housing market. This means that the Chinese housing market takes one more step towards becoming a fully market-oriented market in the socialist market economy.

2.3.2.3 The Development of Housing Monetary Policy

The real estate industry, as a typical capital-intensive industry, is highly dependent on the financial sector. There is a close mutual relationship between the housing market and the banking industry. Any changes of one industry may significantly influence the other sector particularly in China as both industries are deeply under national macro control. Within China's current real estate market, commercial banks have participated in nearly all the processes of housing development. According to an estimate of the People's Bank Research Council, approximately 80% of the land acquisition and real estate development funds, directly or indirectly, come from commercial bank credit. The scale of the fund-raising for real estate agencies is very limited; therefore the real estate business has to rely on the commercial banks, either debt financing for development project loan, or capital raising via pre-sale auction and collecting money from contractors (Ma, 2007). Not only for the suppliers, but also the consumers, they also need mortgage loans for purchasing houses from commercial banks.

So the commercial banks, directly or indirectly, take market risks and credit risks during each stage of the housing market operation, through various forms of credit funds-housing consumption lending, real estate development loans, construction firms' liquidity loans, and land reserve loans, etc. On the basis of existing studies, the rapid development of housing market profits originates from loose monetary policy. Although the central bank has implemented many moderate and even tight monetary policies in the recent years, under the stimulation of rising property prices, bank credit expansion is still 'unstoppable'. The expansion of the money supply has strongly supported the huge release of property development and individual housing consumption (Kong, 2010). For instance, He (2007) shows that, by the end of 2005, real estate loans had reached 3070 billion yuan (374.77 billion US$[15]), accounting for 14.84% of total loans from financial institutions and 16.75% of GDP. According to some financial institutions' estimations, the percentage of bank lending in

[15] From the NBSC, the average exchange rate in 2005 is 8.1917 yuan/US$.

real estate development was over 55% by 2005, and mortgage loans on housing was 63% in the first quarter of 2005. Furthermore, the growth rate of real estate loans has been continuously higher than the increase in total financial institution lending, even up to the peak value—34.5% in the first quarter of 2005.

On the other side, the support of monetary policy for housing industry has also contributed to the fast growth of individual housing mortgage loans. The report by the Central Bank points out, that since 1998, the encouragement of monetary policy on the real estate market has been changed from the one side motivation on property enterprises to promoting both sides of investment and consumption. Individual housing loans have become today's most important part of China's individual consumption lending (Kong, 2010). According to the statistical data, by the end of October 2007, national commercial real estate loans have risen to 4690 billion yuan (616.78 billion US$) with a 30.75% growth rate, accounting for 28.9% of total net new commercial bank loans at the same period. Therein, individual housing lending is 2600 billion yuan (341.925 billion US$) with a 35.57% growth rate; housing provident fund loans is 450.22 billion yuan (59.21 billion US$) with a 34.87% growth rate. Under the expansion of the money supply, the sold floor space of commercial buildings has been increasing by an average 20% a year, with the highest recorded level of 45.1% in 2005.[16]

Monetary policy has impacted on the real estate market through two channels: money supply and interest rate (Ahearne *et al.* 2005, Lv *et al.* 2010). From the perspective of the money supply, the data from NBSC shows that the growth rate of money supply (M_2*: money and quasi-money*) has remained above 20% from 1991 to 1996; although slightly dropping afterwards, it still remained around 17%. After the Asian Financial Crisis of 1997 and the Global Financial Crisis of 2007-2008, the growth rate has firmed up to 27.7% again in 2009. With regard to the interest rate policy, the record of the People's Bank of China indicates that the overall trend of the statutory reserve ratios[17] for both large and small financial institutions has steadily risen up since 2004, although the ratios slightly fell down in 2008 due to the 2007 global financial crisis. Meanwhile, the benchmark deposit and lending rates have also kept increasing during the same period, apart from in 2008.

The increases in the interest rate not only corresponds to market prosperity and development needs, but they also reflect the determination of the central government to limit the housing

[16] From the NBSC, the average exchange rate in 2007 is 7.6040 yuan/US$.
[17] 'Statutory Reserve Ratio' refers to a minimum portion (expressed as a percent) of total customer deposits and notes, that each commercial bank must pay as reserves to the central bank.

market, as well as control the extremely high inflation rates. Especially in 2010, against the background of rapidly increasing house prices and excessive inflation, the People's Bank of China raised interest rates as many as ten times, the benchmark deposit and lending rates twice, and the statutory reserve ratio eight times. To some extent, these monetary measures have controlled the growth rate of house prices.

In addition to the interest rate adjustments, the central authority has introduced abundant implementary provisions, which specifically aim at controlling the phenomenon of house price increases to further relieve stess in the Chinese housing market. The housing loan policy has started since 1985, and has been through a dramatic development stage from 1996 to 1999. After 2002, the houisng loan policy has rationally returned to the normal track of development. Since 2010, the China's central government has frequently implemented new housing policies to cool down the overheated real estate market. Particularly, in April 2010, 'New Four Housing Policies' and 'New Ten Housing Policies' have the strongest impact and play a significant role in the Chinese housing market. Figure 2.1(d) illustrates the time line of its development process. Table 2.4 elaborates a series of adjustments for housing loans policies. Overall, according to the status of the Chinese housing market development, the adjustments combine loose and tight policies together in order to guide changes in the housing price trend. For example, the loose monetary policy refers to the discount for housing loan interest rate, and the tight policy includes raising the percentage of down payments for the second apartment. These adjustments have contributed to making a better policy environment for China's housing market.

Table 2.4: The Adjustment of Housing Loans' Policies

Date	***Reforms***
2003.06	The central bank: the down payment % for the first housing purchase is at least 20%, decreasing interest rate by 10%; while for the purchase of high-grade commercial buildings, villas or the second house, commercial banks can properly increase the percentage of down payment.
2005.03	There is no restriction on interest rate cap, and the down payment % for individual housing loan can ascend from 20% to 30%.
2006.05	A notice on adjusting individual housing credit policy: the down payment % of home loans must not be under 30%; while for the apartments less than 90 m^2, the percentage remained at 20%.
2006.08	The central bank: interest rate floor for housing mortgage loan expanded from 90% to 85%, the interest rate of individual housing fund stayed at the same level.
2007.09.27	The central bank and CBRC[18]: the down payment proportions were no less than 20% for apartments less than 90 m^2, and no less than 30% for apartments more than 90 m^2; for second housing purchase, the ratio must be above 40%, and the interest rate must not be

[18] CBRC: China Banking Regulatory Commission

	under 110% of benchmark deposit rate; also, the down payment % and interest rate should significantly go up with the increase number of housing purchase.
2007.10	The central bank failed to make a exact definition of 'the second apartment', and banks declared different standards for 'the second apartment'. Therefore, the new policy for 'the second apartment' fell into an awkward dilemma.
2007.12.05	The central bank and CBRC: for individual home loans of the second apartment, if per capita housing area is still lower than the local average level, the consumer can apply for the discount of home loan interest rate as well as the first apartment.
2008.10.22	The notice was declared by the central bank: since 2008, commercial banks can supply a 70% discount for housing loan interest rate to clients on the basis of the standards for the first time purchasing houses.
2008.10.27	The central bank clearly pointed out that the interest rate floor of individual home loans expanded to 70% with the 20% down payment. The government work report in the NPC[19] and CPPCC[20] claimed that 'the second apartment buyers, who are fit for the policy requirements, can apply the discount for housing loan interest rate '.
2008.12.20	General Office of the State Council: for individual housing loans of the second apartment, the consumer can also enjoy the discount of home loan interest rate if per capita housing area is still lower than the local average level.
2009.01	In Beijing, the second apartment policy was released by Beijing Municipal Construction Committee, Beijing Development and Reform Commission, Beijing Finance Bureau and Beijing Local Tax Bureau; the proportion of down payment was adjusted as the same as the first apartment.
2009.06.22	CBRC: commercial banks cannot neither define the standards for 'the second apartment' by themselves, nor lower the down payment percentage by any means.
2010.01.07	A notice on promoting the healthy development of real estate market is announced by the State Council: reasonable guide housing consumption, reining in the speculative housing purchase, increasing the percentage of down payment for second home loan to 40%, and continuously practising housing tax policies with differentiation.
2010.04.12	Five largest state-owned commercial banks[21] tighten home loan interest rate. ICBC increases the discount rate of housing loan interest rate from 70% to 85%; ABC and CCB call of the discount for second housing loan interest rate; BOC sets up the home loan interest rate as 110% of benchmark deposit rate; BC means to conduct new policy for housing mortgage loan.
2010.04.15	The State Council announced four concrete measures in order to slow down the excessive growth of house prices ('New Four Housing Policies'): the down payment % must be over 30% for the first purchase of over 90 m^2 housing; the ratio must be above 50% for the second housing home loans, and the loan interest rate must not be under 110% of the benchmark deposit rate; the down payment % and loan interest rate have to significantly increase for families with consumption on the third housing.
2010.04.17	Only two days after the announcement of 'New Four Housing Policy', the State Council took another ten concrete steps to press down increasing housing price ('New Ten Housing Policies').
2011.01.26	The State Council announces that the down payment percentage of second housing home loan is raised up to 60%.

Source: Sohu Focus 'The Review of Policy Adjustment in Recent Years' http://house.focus.cn/news/2011-01-27/1180107.html

2.3.2.4 The Development of Population Policy

China, as a fast growing economy, has been experiencing one of the most rapid urbanization processes in the world. As mentioned before, China's urbanization rate was only 19% in 1980,

19 the National People's Congress
20 Chinese People's Political Consultative Conference
21 Five largest state-owned commercial banks in China: Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), Bank of China (BOC), China Construction Bank (CCB), and Bank of Communication (BC)

and grew to 45.66% in 2008; while it is expected to reach 52.28%, 57.62% and 67.81% in 2015, 2020 and 2030 respectively[22].

On the basis of China's special Household Registration System (*Hukou*), the annual urban population growth can be distributed into two components: one is the natural growth of the existing urban residents, and the other is the net urban migrants with urban household registration transformation.[23] According to Chen *et al.* (2010, Table 1), over 1991 to 2005, the natural increase of urban citizens remained stable and only accounted for a small part of the total growth of new city population. Comparatively, the main source of city dwellers growth contributed to the net official rural-to-urban migrants. Especially, after 1995, the disparity has been increasingly aggravated between the natural growth of urban citizens and the net migration to cities.

It comes to a further conclusion that the net migration with official household registration transfer is the primary source of urbanization in China and takes up to 90% of new urban immigrations. Not only have the new official migrants from rural areas added to the demand for housing in cities, but the floating population without household registration transfer theoretically may also cause a thriving housing demand in urban areas. Since unlike the official urban residents, the floating population could not enjoy the equal treatment to purchase the affordable houses. Instead, either the floating migrants with higher economic capability have to purchase commodity buildings in the primary housing market to meet their housing needs, which further causes house price inflation; or the lower-income floating population have to live in the shanty town-the substitutes of affordable houses in the secondary housing market.

2.4 Achievements of Chinese Housing Reform

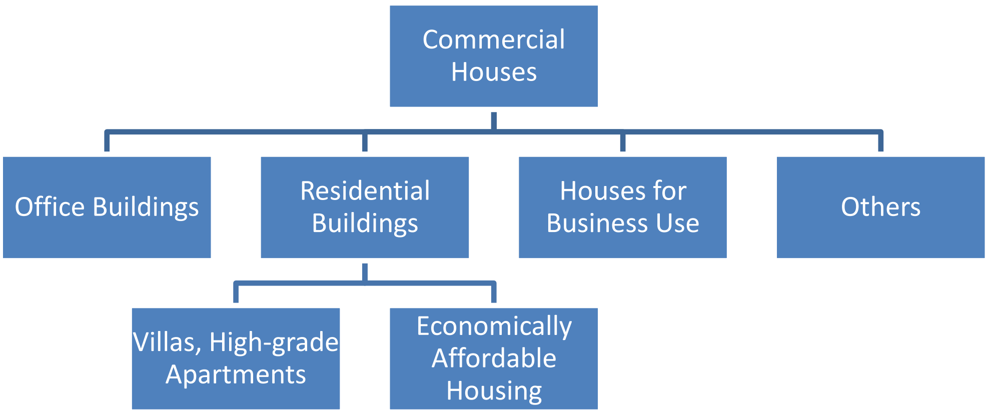
Through three decades of Reform & Opening and the rapid expansion of the Chinese Real Estate Industry, the Chinese housing market has achieved significant improvements in many fields, such as the diversification of housing types, high home ownership, and the rapid growth of housing built/sold, residential investments and per capita housing space.

[22] The data is from the 'Macro-Economy Blue Book' published by the Chinese Academy of Social Sciences on 15th April 2010.

[23] Migrants without the official transformation of household registration (*Hukou*) are defined as floating population and usually excluded from urban population in the official statistical survey and census in China.

2.4.1 The Diversification of Chinese Housing Types and Home Ownership Ratio[24]

After housing reforms, commercial houses have been produced in many formats instead of the single welfare housing modality, in order to meet customers' needs at different levels. Figure 2.5 shows the classification of buildings in China. The houses in the market can be divided into many groups: the welfare housing assigned to employees, the commercialized buildings etc. For instance, the commercial buildings include economically affordable housing, which is very cheap as with the welfare houses but different from welfare houses. The welfare houses are used by employees because they have paid a certain proportion of their wage into a house funding, while the economically affordable housing is also determined by the market, but under the authorities' control and administration. Thereby the prices can greatly differ between different houses.



(Source: China Statistical Yearbook, National Bureau of Statistics of China http://www.stats.gov.cn/)

Figure 2.5: The classifications of Chinese commercial houses

Generally speaking, home ownership has risen dramatically during this period. Gao (2010) demonstrates there are two major sources for housing ownership: either purchasing existing public housing or acquiring newly constructed commercial buildings. In 2005, MOC (2006) illustrates the percentage of homeowners in urban residents with '*Hukou*' holders as 81.62%. While in accordance with 'Report on the Status of the Cities in China 2010/2011'[25] published on 4th October 2010, this number has reached to 87.8%. Furthermore, the conditions of urban residences have been improved substantially. By the end of 2008, the proportions of urban

[24] Home ownership ratio means privately-owned housing-houses inventory of all society ratio.

[25] 'Report on the Status of the Cities in China 2010/2011—City, Make Your Life Better'. Published jointly by the China Science Center of International Eurasian Academy of Sciences, China Association of Mayors and United Nations Habitat (UNHABITAT).

home holders, living in single buildings and apartment units, are 4.5% and 83% respectively. In contrast, only 12.5% of householders live in tube-shaped apartments[26] or bungalows.

2.4.2 Demand and Supply Sides of Housing Market

With massive urbanization and rural-to-urban migration, the demand for housing is expected to continuously rise in urban areas. On 25th March 2010, a report produced by the UN, points out China's urbanization rate was only 19% in 1980, but it will be as high as 47% and 59% in 2010 and 2025 respectively. 'The Macro-Economy Blue Book', published by CASS[27] on 15th April 2010, also predicts vigorous growth of the urbanization rate in China. As the Blue Book said, this rate was 45.66% in 2008, while it will substantially grow by up to 52.28%, 57.62% and 67.81% in 2015, 2020 and 2030. The high expected urbanization rate reflects the expected increase in urban residences, and further is a reflection of the demand for urban dwellings.

In the meantime, the supply of urban residential buildings has grown increasingly to match the demand side in the housing market. The statistics data from NBSC illustrates that the residential building completion (the supply side) in 2009 has grown approximately by three times compared to 2000, while the floor space sold of residential buildings (the demand side) has increased more sharply from 165.7 million m^2 to 861.85 million m^2 over the same period. Moreover, between 2000 to 2009, the completed floor space always exceeded the amout sold in the initial years. However, since 2005, the level sold has been higher than the amout completed. Clearly, the persistent imbalance between market demand and supply might become one of the essential reasons driving the house price growth.

2.4.3 Residential Investments

Among the three key macro variables--investment, consumption and export—of China's economy, investment has always played a profound influence on China's macro-economy. More specifically, real estate investment has been widely regarded as a significant indicator of a healthy economy. Since 1979, responding to the call to enhance people's living standards and more liberal economic development policies, the state has invested in the real estate

[26] 'Tube-shaped Apartment' is a typical housing style with Chinese characteristics, which is a product of Chinese state-owned enterprises welfare housing system in 1970s and 1980s. These buildings are dormitories with the long corridor, shared toilets & kitchens, and the same size individual rooms, usually less than 20 m^2 for each room.
[27] the Chinese Academy of Social Sciences (CASS)

sector to a remarkable effect. Based on the statistics of the NBSC, in 2009, the investment in new residential building construction has increased nearly ten-fold from 380.64 billion yuan (55.722 billion US$) to 3642.8 billion yuan (533.275 billion US$)[28]. Also, at provincial level, the real estate investment has gone through a dramatic expansion. Taking the three most fast developing provinces—Beijing, Shanghai and Guangdong--as examples, in 2001, the gross fixed asset investments were 151.33 billion yuan (18.283 billion US$), 200.46 billion yuan (24.219 billion US$) and 348.44 billion yuan (42.097 billion US$) respectively[29]. By 2009, this climbed up to 461.69 billion yuan (67.587 billion US$), 504.38 billion yuan (73.837 billion US$) and 1293.31 billion yuan (189.33 billion US$) respectively with the rate of increase as 205% for Beijing, 152% for Shanghai and 271% for Guangdong[30].

2.4.4 Per Capita Housing Space

Although under the pressure of migration to urban cities and constant imbalance between market demand and supply, the housing reform has promoted the increase in the available housing. 'At the very beginning of the reform in 1980, the average housing space standard was only 7.18 m^2 per capita, then slightly raised to 10.02 m^2 per capita in 1985, despite that 26.5% of urban residents was still either homeless or suffered from overcrowding' (Tang, 1989). The urban population was only 172.45 million accounting for 17.92% of the total population in 1978, but had a huge leap forward to 606.67 million, 45.68% of the total population by 2008 (NBSC 2009 Year Book). Meanwhile, the average living space for urban individuals has risen steadily since the Reforms. In addition, the vice minister of MOHURD[31] has pronounced that the housing space per capita would reach up to a historical new high—28 m^2 per capita—in 2007, representing a dramatic improvement in the Chinese housing reform. However, the actual number would drop downward to 22 m^2 if migrant urban residents without official registration (*Hukou*) are also included in the urban populations. Even so, we should believe that such an achievement is difficult, since China has been experiencing contemporaneously high-speed urbanization process over the same period.

[28] From the NBSC, the average exchange rate in 2009 is 6.8310 yuan/US$.
[29] From the NBSC, the average exchange rate in 2001 is 8.2770 yuan/US$.
[30] From the NBSC, the average exchange rate in 2009 is 6.8310 yuan/US$.
[31] The Ministry of Housing and Urban-Rural Development (MOHURD)

2.5 The Major Problems of the Chinese Housing Market

2.5.1 Housing Inequities for Householders with Different Income

Housing reform has effectively increased people's living space and relieved the heavy housing financial burden of governments. During the progress of privatization across the country, although the disposable income of urban residents has sharply risen and the problem of housing shortage has been partially resolved, the income disparity between the rich and the poor has increased among urban areas on a national scale (Zhao and Bourassa, 2003). According to the statistics of NBSC, the highest-grade disposable incomes per capita of 6 provinces are all above 20000 yuan (2927.829 US$) in 2009.[32] Also the first and second highest income is 28838 yuan (4221.637 US$) in Shanghai and 26738 yuan (3920.802 US$) in Beijing, which is approximately 2.4 times the lowest income province Gansu with only 11930 yuan (1746.45 US$) per capita. Not only in crosswise comparison, but also in longitudinal form, there also exists a huge gap between the top 3 provinces and the last 3 provinces. Figure 2.6 shows the disposable income gap between the top 3 and the last 3 provinces over the last few years. The developmental level of the richest regions has been nearly 10 years ahead of the poorest regions. More specifically, the income level of Shanghai in 1996 was equal to Gansu's income level in 2005, while the per capital disposable income of Gansu in 2009 was similar to Shanghai in 2000.

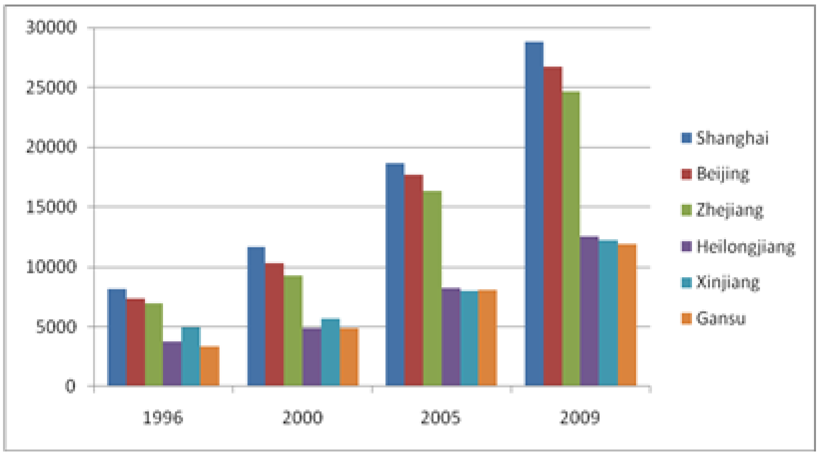


Figure 2.6: The Disposable Income Gap between the Top 3 and the Last 3 Provinces over Few Years

Not only that, according to the National Statistics Yearbooks (NBSC, 2007), the house price to income ratios in China's biggest cities have remained at around 20 (Ma, 2005), which are

[32] From the NBSC, the average exchange rate in 2009 is 6.8310 yuan/US$.

significantly higher than the recommended standard of 3-6 by the World Bank. 'Even in developed countries such as the United States, the median housing price-household annual income ratio is rarely over 8 in most regions' (Gao, 2010). Particularly, in most major cities in China, the ratios of average housing price to the middle-to-lower income families are much higher than those in developed countries. What's worse, the gap in these ratios between mid/low- and high- income families has been enlarged in recent years (Jin, 2006). For instance, in 2005, the house price to annual income ratio was 22.69 for the urban lowest income residents (the bottom 20% income households), while it was only 2.45 in highest earning families (the top 20% income households). Compared to the global average levels, these two ratios for mid-to-low and high income householders are 9.7 and 5.6 respectively.

The rapidly rising house prices probably worsened social and political stability in China, without appropriate housing policies to satisfy the demand for affordable and low-rent houses. Therefore, housing inequities have become one of the major sides of social injustices causing social unrest in many regions in China. In recent nationwide urban development programmes, such as large-scale removal and rebuilding, even with the sizeable compensations from the governments, many householders or units relocated due to building demolition were still reluctant to move out of their old and subpar buildings, for fear of not being able to afford new dwellings. In some extreme cases, in order to expropriate the land, the authorities take some compulsory means, such as cutting off maintenance services; but the residents resolutely refuse to move out of their old houses even without the supply of water and electricity (Chen, Wei and Xiang, 2006). Either the developers have to increase compensation for householders, or there might be a violent conflict between householders or units and developers or local authorities (Xiao and Yang, 2008).

On the basis of the three-tier housing regime after the housing reforms (Yiu, 2010), the housing demand of mid-to-low and low income householders should be satisfied by the affordable housing and low-rent dwellings system. However, since the prime commodity housing market for high earning families appears much more profitable, most of the newly built constructions have been targeted at top grade private apartments, while the government could not provide a sufficient supply of affordable public welfare houses for mid and low income individuals. Thus it can be seen, the current housing system design does not correlate very well with Chinese income distribution. On the one side, rich people possess much more housing units than they need; on the other hand, the majority of the population cannot afford the dwellings available in the housing market and have to rely on the public welfare housing system, which comprises only a small portion of the whole housing supply (Gao, 2010).

2.5.2 Lack of Sufficient Affordable House or Low-Rent Housing Supply

Another evident problem of Chinese housing market is the lack of sufficient affordable house or low-rent housing supply for middle-to-low income populations. Although one of the primary objectives of Chinese housing reform is to guarantee mid-to-low families affordable housing or low-rent housing; as a matter of fact, the actual demand for housing has far exceeded the annual completion supply of affordable house. Since the most important target of the real estate developers is to maximize the returns on their capital investment, while doing such projects for middle-to-low income householders is not as profitable as doing commodity buildings for middle-to-high income homeowners; therefore, they lack incentives to develop affordable house or low-rent housing.

Over the past decade, China's central authority has budgeted at vast expenses to support the affordable/low-rent housing projects, the largest project known as '*An Ju Gong Cheng*'. 'In 1998, the government spent a total of 80.6 billion yuan (9.735 billion US$[33]), which was about 0.99% of GDP, to build affordable housing. In 2003, the government expenditure on affordable housing construction increased to 157.8 billion yuan (19.065 billion US$[34]), which was 1.35% of annual GDP' (Jin, 2006). In addition, the real estate developers are encouraged to construct such projects by purchasing land at a much lower cost than market value, 'on condition that a certain percentage of the acquired land was to be developed for price-limited housing projects' (Gao, 2010), which term of transaction is called 'land-for-housing approach'.

However, the effectiveness of these arrangements has not been satisfactory. The reality is that the government-funded affordable/low-rent houses are far behind in fulfilling the requirements of middle-to-low income families. As a result of the profit maximization, with the 'land-for-housing approach' of acquiring land, the real estate developers have always constructed other projects, such as 'luxurious apartments and mansions for the elite' (Gao, 2010), to replace the affordable/low-rent housing project. Worse than that, the local authorities usually motivate such behaviours, because selling the high-priced commodity

[33] From the NBSC, the average exchange rate in 1998 is 8.2791 yuan/US$.
[34] From the NBSC, the average exchange rate in 2003 is 8.2770 yuan/US$.

housing can dramatically contribute to the growth of GDP and financial revenue for local economy. Based on the data from NBSC, the total constructed floor space of affordable/low-rent houses has been persistently increasing over 2000 to 2009, but the proportion of affordable housing to total constructed floor space has been decreasing. Similarly, not only the completed floor space of affordable houses but also the percentage of affordable houses to total completed floor space has presented a decreasing trend during the last decade.

In order to reveal how greatly different revenue can be made between building villas/individual apartments and affordable/low-rent houses, there is a specific case of Vanke Real Estate Group, the largest real estate developer in China. As we can see from Table 2.5, there are three examples of their housing projects in Shanghai: 'Lan Qiao (Orchid Woods), which hosts single family houses of around 280-480 m^2 in lot size; Hong Du (Red Capital) center, which is home to townhouses and multifamily houses; and Hong Qiao (Rainbow Bridge), an affordable housing project. Considering the space occupancy rate for each project, the Lan Qiao project has the highest land waste rate, while the affordable housing Hong Qiao project has the lowest. However, considering the huge difference in selling price per square meter lot size, and in building costs per square meter lot size, in 2006, Vanke actually made the highest profit from the most land-wasting Lan Qiao project, and the least profit from the affordable housing Hong Qiao project'(Gao, 2010). In light of this case, it is easy to understand why there is lack of sufficient affordable/low-rent house supply in China's real estate market, even with the central government provision.

Table 2.5: Cost and Profit Comparison across Different Housing Projects of Vanke

Project	**Lan Qiao**	**Hong Du**	**Hong Qiao**
Type	Single family house (villa)	Multifamily house (apartment)	Affordable/low-rent housing
Space Occupancy Rate (%)	30	86	92
Sales Price (yuan/m^2)	40000	20000	4200
Construction Cost (yuan/m^2)	2000-3000	3000	4000
Profit (yuan/m^2)	37000-38000	17000	200

Source: Gao (2010) Box 1

In response to the incentives of real estate developers to replace the affordable housing projects, China's central authority has implemented more detailed and compulsive regulations, such as the '90-70' policy. In 2006, the central government issued a declaration that real estate developers are obliged to allocate 70% of the total area in each of their new housing projects to 'affordable housing', i.e., smaller than 90 m^2 per unit (thus the nickname '*90-70*' units). The intention of ’90-70’ policy is to satisfy the housing demand of middle-to-low income householders; however, according to an anonymous official source, in the first five months of 2007, ‘90-70’ projects only accounted for 17.2% of all invested housing projects all over China (Gao, 2010).

Based on Gao’s research (2010), due to the huge profit difference between affordable houses and luxury apartments, real estate developers have a strong motivation to seek ways around the ‘90-70’ policy minimizing the negative influence of such policy. Their strategies include: (1) building walls surrounding their acquired low-cost land to wait for opportunities to switch land usage in the near future; (2) altering construction plans to allow combining multiple neighboring ‘90-70’ small units into luxurious spacious larger units for home buyers not falling within the low-income group; (3) enlarging the space of the balcony, which is only counted as half of the living area by China’s national construction standard; hence, the final products can still be sold as luxury units with sizeable living area and spacious balconies.

On the other hand, since the local governments are eager to generate higher government financial revenue and to stimulate local economic development by pushing the upscale housing market instead of fulfilling the housing needs of the lower-income group, the local political leaders were behind real estate developers. This helped deflect the intention of the ’90-70’ policy by building more affordable/low-rent housing for the lower-income families. More specifically, many local authorities promoted real estate developers to accumulate vacant land intended for the affordable housing, but not to develop it and wait until the policy changes in the near future. For example, as Shanghai municipal government required, developers have to maintain 70% of the under-construction projects to be affordable housing projects (in compliance with the 90 m^2 rule). However, developers are allowed to maintain 100% of the projects to be large-unit apartments in regions with expensive housing prices (therefore higher profits) such as the downtown area. In this way, the excess profits from the lage-unit projects in high-price regions offset the ‘losses’ of the affordable housing projects. Other local authorities adapted the ‘90-70’ policy but to minimize its impacts as well.

In addition, the strict ‘90-70’ policy even led to housing prices to rise further. When the few new housing projects according to such strict ‘90-70’ rules were brought into the market starting from early 2007, surprisingly, these intentionally designed small apartments even caused a new round of price increases. One specific case is the ‘Shanghai Olympic Garden’ in Songjiang (a suburban town close to Shanghai). The previously existing apartments in the project were sold at around 8000 yuan/m^2 (1052.078 US$/$m^2$)[35] in early 2007. With its third phase construction completed, about 266 newly constructed ‘90-70’ units were released in July 2007. To the surprise of home buyers, the unit price was even higher at nearly 10,000 yuan/m^2 (1315.097 US$/$m^2$)[36]. Meanwhile, because of the fact that only 30% of newly-completed units were bigger than 90 m^2, the price for such bigger apartments sharply grew up in different cities.

In short, the new regulation is pushing housing prices higher rather than providing an increase in low-price housing supply. Thus, it can be seen that the good intent by the central government to implement the strict ‘90-70’ policy to real estate industry did not result in more convenient and affordable housing units which suit people’s housing demand. The failure of the ‘90-70’ policy clearly demonstrates the ineffectiveness and insufficiency of simply using administrative tools from the central government in the Chinese housing market.

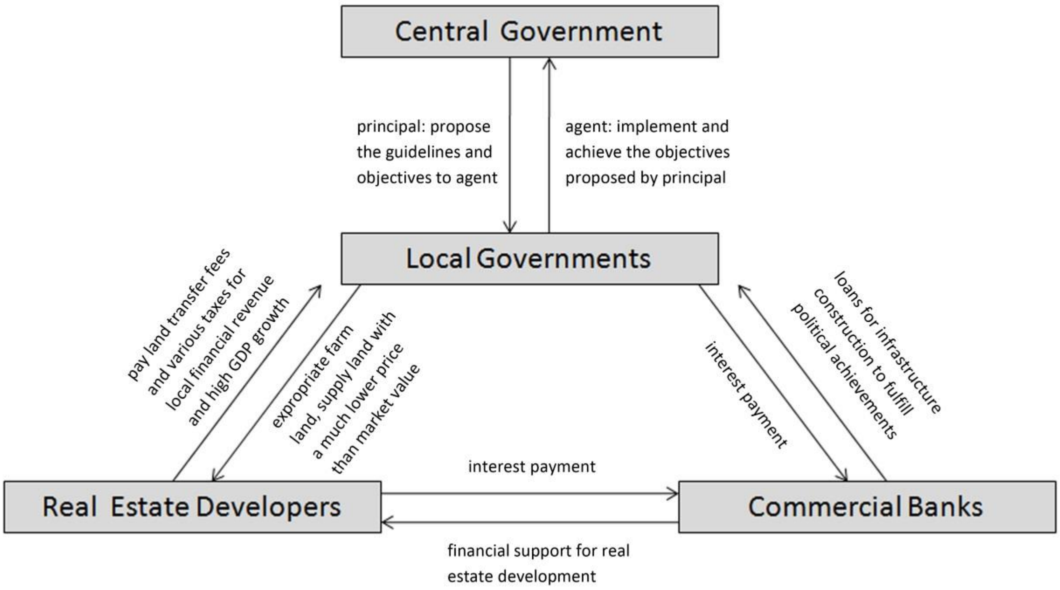
2.5.3 Principal-Agent Problem

In light of the housing reform since 1998, the land transfer policy has been through a variable revolution over time. In 2002, the implementation of a new bidding auction listing land transfer system has marked the marketization of China’s land use right transaction. Naturally, land transfer fees have now become one of the major sources of financial revenue for local authorities. As mentioned above, the discretionary self-interest among different levels of governments have generated the inconsistency of regulations and policies on controlling Chinese house prices.

One of the most apparent problems is the ‘Principal-Agent’ problem between central government and local governments. As the ‘principal’ part, the central government has two primary goals: the long-term objective is to sustain a high growth rate of economic development; meanwhile, in order to ensure a stable social and political environment for sustainable economic growth, it is necessary to meet the demand of a majority of citizens for daily necessities, such as housing demand. The central government needs to achieve governing goals through sub-level authorities, which are local governments. In this case, local authorities have played a part of ‘agent’, who fulfils the objectives proposed by their principal, the central government (Gao 2010).

[35] From the NBSC, the average exchange rate in 2007 is 7.6040 yuan/US$.
[36] From the NBSC, the average exchange rate in 2007 is 7.6040 yuan/US$.

In the Chinese real estate market, the interests of local governments, real estate developers, and commercial banks have become entangled with each other. Figure 2.7 demonstrates the mutual relationships among every party of the housing market: the central government, local authorities, real estate developers and commercial banks. In order to achieve the central government's goal of high GDP growth and financial revenue, the local governments have transferred land use rights to real estate developers by even expropriating farm land; meanwhile, real estate developers have paid high land transfer fees and various taxes to the local authorities.



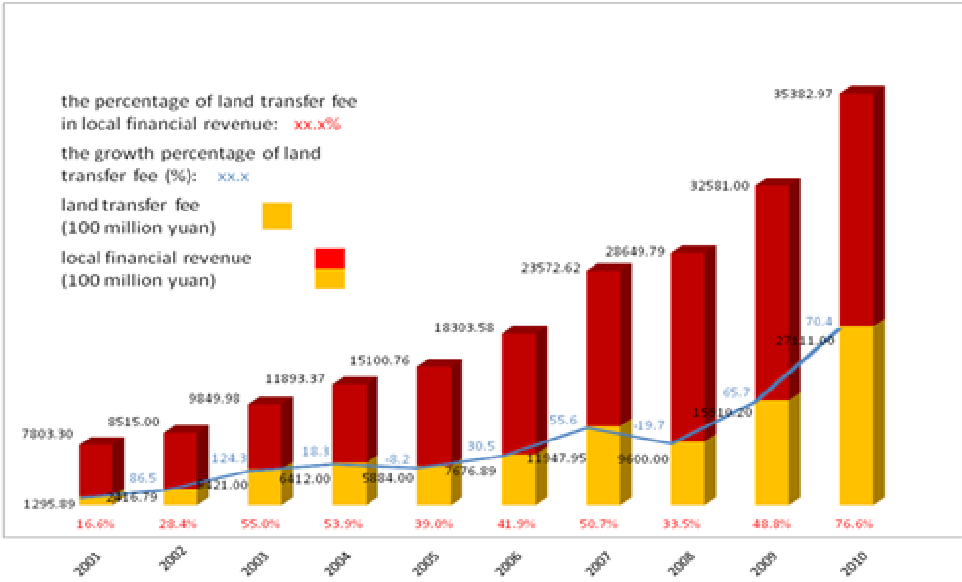
(Source: Author's summary)

Figure 2.7: The Mutual Relationships of Each Party in the Chinese Housing Market

As the 'Cash Box' of local governments, the land transfer fees have reached up to 2700 billion yuan (398.848 billion US$)[37] in 2010. It can be found from Figure 2.8 that the high speed of land transfer fee growth over 2001 to 2010. In 2001, the percentage of land transfer fees was only 16.6% of total financial revenue, while the percentage has accounted for 76.6% of local financial revenue with an increase rate of 70.4%. China's land market has presented a trend with the growths of both the quantity and the price of land supply. More specifically, three cities, Beijing, Shanghai and Dalian, have moved into 'Hundred Billion Club', with total land transaction fees 160 billion yuan (23.635 billion US$), 150 billion yuan (22.158 billion US$) and 110 billion yuan (16.249 billion US$) respectively. The price element has an outstanding contribution on the growth of urban land transfer fees. For instance, according to

[37] From the NBSC, the average exchange rate in 2010 is 6.7695 yuan/US$.

a record, the land transaction area of Wuhan and Nanjing has grown by no more than 20%, but the land transfer fee has increased more than 125%.



(Data Source: Southern Weekend Newspaper, 13th January 2011. Available from: http://www.infzm.com/content/54644)

Figure 2.8: The Growth Rate and Percentage of Land Transfer Fees 2001-2010

In recent years, the real estate market has largely contributed to the local economic output; meanwhile, GDP growth has become the most important evaluation element for local authorities. As a consequence, more and more local governments over depended on the land transaction and real estate development projects to fulfil the local financial advantage and GDP growth. The local authorities have relied on ‘real estate development as an important political tool to enhance their own political power and reputation within the governing system’ (Gao, 2010). As Gao (2010, Table 3) stated, in 2006 the highest percentage of land transfer fee in terms of local GDP was nearly 7% in Chongqing, and the percentage of land transfer fee in terms of local revenue was as high as 96.05% in Fujian. Even for the average level, this index in local revenue was 40.96%. Another overall trend was that, the less developed the region, the higher the percentage is. This phenomenon has raised much concern for a series of social problems, such as violent/forced demolition and rapidly rising house prices.

As the principal party, the central government has implement a series of policies to control and regulate the land market and real estate market; while, as the agent party, the local governments, who fell into a financial dilemma, have racked their thoughts to expand the sources of land finance. The ‘common tricks’ include bidding to host various conferences and festivals, expropriating farmland in the name of ‘new rural community construction’, the construction of affordable housing projects, the urban renewal of old cities, and so on. The local authorities expropriate land and remove the rural/urban residents into the concentrated residence area; afterwards, they transfer land use rights to real estate developers by bidding-auction-listing channels, and finally get a huge amount of land transaction fees. In addition, hosting festivals and constructing new cities, not only raises financial income for local GDP growth, but also promotes the city image manifesting the political achievements.

2.6 Summary of the Chinese Housing Market

As our review shows, since reform and opening-up in 1978, the Chinese housing reform has experienced thirty years development with two overall stages: the pilot trial stage from 1978 to 1991 and the real estate market development stage from 1992 to the present. More specifically, these two big stages can fall into four sub-steps: the gestation period (1978-1988), the start of the real estate industry (1990-1995), the quick development stage (1998-2002), and the housing industry adjustment period (2002-now).

Before 1978, the old housing system was the socialist welfare housing system and the houses were provided almost free by government organizations and state-owned enterprises/work units. In the first stage, the housing reform trials were carried out in selected areas only by selling public housing at cost price and rising public housing rent. All the land rights for housing were state-owned, and state-owned enterprises did not need to pay for any fees for land using. Meanwhile, the real estate market has started to appear and the housing loan policy has started in 1985; while most people still lived in work units' dormitories and only a small number of individuals had their own apartments.

Moving to the second stage, the central government formally approved a ground land lease system in 1990, and then the first property boom appeared between 1992 and 1993 on a national scale. In 1994, the Chinese central authority promulgated 'The Decision on Deepening the Urban Housing Reform', which founded a comprehensive framework for housing reform and further listed the details in the next stage. In 1995, the 'Decree 6--Rules for the Implementation of the Interim Regulations of the People's Republic of China on Land Value-added Tax' was promulgated and applied Value Added Tax (VAT) to rental value of land. However, the housing loan development was still in the exploratory stage. Under the promotion of the implementation of these policies, some large real estate companies set up, such as the Chinese first and largest real estate company, Vanke.

During the third period, against the fast urbanization background, more positive policies have been approved covering for many sectors: housing reform policy, land policy and housing loan policy. According to the State Council announcement[38] in 1997, the welfare-room system changed radically. In 1998, another milestone of the housing reform came up when the central government announced 'A Notification of the Urban Housing System and Accelerating Housing Construction', which means an end to the welfare allocation of urban housing. In the meantime, Land Administration Law of 1998 reaffirmed substantial balance policy and retrenches regulations on farmland conversion, which indicated the new restrictions on residential housing land were promulgated; furthermore, in 1999, the Decree 39, 'Circular on Strengthening Management of Transfer of Land and Strictly Banning Speculative Land Dealing', was also issued by the General Office of the State Council. This period also saw a dramatic development stage of housing loan policy. With the support of housing home loan, a number of urban citizens have bought their own apartments by borrowing the housing mortgage.

Finally in the present stage, in order to control the overheated development, the Chinese housing market has stridden forward into an adjustment period. In 2002, the Ministry of Land and Resources issued the competitive bidding, auction and listing-for-sale transfer policy for the right to use state-owned land as profit-oriented land. 'The Bidding Auction Listing Transferring State-owned Land Use Rights Provision' has largely accelerated the marketization process of the Chinese housing market. Following this, the State Council issued 'No. 18'[39] document in September 2003, which was the first time publicly that the real estate industry has been accepted as a pillar of the national economy and that the housing market required sustainable and controlled development. In 2004, the remarkable boundary of land policy, 31st August 2004, so called '8.31 major limit of land granting', implied the last deadline of ending land agreement transfer. Since then, a new bidding auction listing land transferring system was finally built up.

Moreover, since March 2005, the State Council, Ministry of Construction and other government departments not only made policies to stabilize house prices, but also issued policies to enhance the management of real estate taxation. In 2006, the General Office of the State Council also passed the Opinions of nine ministries and departments including the Ministry of Construction. The opinions indicated the demand to construct middle-and-small

[38] This announcement was carried out to speed up and reform further the construction of the housing system.(3rd July,1997)
[39] See Footnote 9.

sized commodity houses for sale to low or intermediate income families. Meanwhile, in order to regulate the housing mortgage behaviours, the central bank of China has constantly escalated the ratio of down payment of home loans. This ratio has risen from 20% initially in 2003 to 60% for the second apartment purchase in 2011. Especially in recent years, there have been growing calls for the regulation and restriction of the Chinese housing market.

After three decades of housing reform, the real industry has become a major contributor to the nation’s economic growth. Under the current housing system, there are three tiers: (1) top tier—private commodity housing for high income families; (2) middle tier—economically affordable housing for mid-to-low income families; (3) lowest tier—low-rent housing for the lowest earning families. As we can see, the Chinese housing market has achieved great success in many aspects, such as the diversification of housing supply channels, the increase of residential investment, the improvement of floor space per capita and living standards.

However, the Chinese housing market also faces some significant challenges and problems. For example, there exist severe housing inequities for householders with different income levels, and the house price-to-income ratio is much higher than the international standard level. Moreover, although the living standards have been improved on the overall level, there is still a lack of sufficient affordable housing/low-rent housing for low income citizens. Thus, a huge amount of slums and shanty towns have risen in response to the lack of housing supply. In addition, a principle-agent problem for land transfer fee persistently exists between the central government and local authorities in the long run.

Based on above, the following chapters will penetrate deep into the impact factors of the Chinese housing market to analysis how these factors affect the Chinese house prices. Through the empirical research, the next part of this thesis will focus on the answers to what decides the Chinese house prices, whether there is convergence between regional house prices and how the housing conditions affect people’s subjective well-being. After the theoretical and empirical research, this thesis aims to give some policy recommendations and suggestions to resolve the existing challenges of the Chinese housing market.

Chapter 3—Empirical Analysis of Determinants of China's Housing Market

3.1 Introduction

Following a discussion of the Chinese housing market background, this chapter is going to examine the fundamental determinants of Chinese house prices. That is crucial to determine the true reasons for the consecutive growth of real estate prices, and how dynamic forces affect house prices.

The existing literature has proposed that, the major factors determining Chinese house prices fall into two aspects—the demand side and the supply side. Wherein, the demand-side elements may include GDP, income, demographic factors, housing consumption, monetary factors and so on; while the supply-side factors may contain land factors, investment, housing units completed, construction costs and so on. In addition to the determinants, we also summarise the common methodologies and models adopted in modelling Chinese house prices, which include the OLS model, VECM model, VAR models and GMM estimations. Broadly speaking, different researchers have reached distinctive conclusions about the Chines housing market, where possible reasons for these inconsistent positions could be due to the differences between data, methodologies and models.

Based on the existing studies, this chapter will use the panel data from 1999 to 2009 across 30 provinces/cities in China. And the explanatory variables are developed to explain the house prices, including disposable income, urban population proportion, unemployment rate, statutory reserve ratio, housing consumption, excessive housing demand, construction cost, urban land use tax, and investment completed.

Although the most popular panel data models applied by Chinese scholars are VAR models, there are still some pitfalls of using the VAR. But the more advanced GMM estimations have not as yet been popularized in modelling Chinese real estate prices. Thus, this chapter will develop the dynamic panel data model with GMM estimation, by starting with basic OLS models, then to fixed effects or random effects, further to instrumental variables models and eventually to GMM estimators. Meanwhile, the long-run equilibrium of the dynamic models has also been studied. In addition, the Sargen/Hansen test for Overidentification, the Arellano-Bond test for autocorrelation, and the robustness checks, all indicate the efficiency of our GMM regressions.

Through the empirical studies, we can conclude that Chinese house prices are more significantly affected by policy shocks, such as monetary policy and land policy, rather than market factors, such as population growth and construction cost. That gives a signal of a non-fully market-oriented housing market in China, and suggests the government could use the policy instruments to regulate and control China's house prices.

Generally, there are six sections in this chapter. Firstly is the 'Introduction'; the second section is the 'Literature review'; next is the section on the 'Methodology', followed by 'Data sources and description'; then the fifth part is 'Empirical results'; the last part is of course the 'Conclusion'.

3.2 Literature Review

There are some fundamental questions about the housing market and the macroeconomy (Leung 2004), such as: 'How are the housing market and the macroeconomy interconnected? Is it important to include the housing market in macroeconomic analysis, and vice versa? What is, and should be the scope of macro-housing research?' The common view is that housing constitutes a significant share of the overall macroeconomy, with some stylized facts illustrating the significance of the housing market in the macroeconomy. There is a productive literature reviewing the intricate interactions between the housing market and macroeconomy, for instance it acts as a wealth effect in the consumption function. Here, we concentrate on the related work of investigating the determinants of China's housing market and how these factors affect Chinese house prices. As summarised in the last chapter, there are many factors that have been tried by many other researchers, such as the growth of GDP and income, rapid urbanization with large population immigration, insufficient housing supply, land shortages, ineffectiveness of regulations, cultural preferences and investment speculation. The following sections are going to discuss the most critical influences and models used in the Chinese housing market.

3.2.1 The Impact Factors of Chinese House Prices

3.2.1.1 Macro-economy Factors: GDP and Disposable Income

The two strongest impetuses on house prices are the rapid development of China's economy and the remarkable improvement of people's living standards, which have arguably done most to promote the rise in Chinese house prices. Since the reform and opening-up, the growth rate of China's GDP has been maintained at an impressive speed. Especially after the 1990s, this rate has been kept as high as around 10%. During 1992-1996 and 2003-2007, the growth rates were above 10%. Even over the period of 1997 Asian Financial Crisis and 2007 Global Financial Crisis, the growth of China's economy has always been sustained at no lower than 7.6%.

As a result, the people's living standards have caught up with the increase in GDP. More specifically, per capita GDP and disposable income are both increasing sharply. Table 3.1 illustrates the strong growth of the nationwide GDP and average per capita disposable income in the past 10 years. It can be seen that the increases of GDP and disposable income are much stronger than of house prices and rental indices. However, the accretion of the housing rental index has lagged behind, not only GDP and disposable income but also the house price index, which indicates some unusual and interesting phenomena in the Chinese housing market.

Table 3.1: Nationwide GDP Index, Average Disposable Income Index, Average House Price and Rental Indices, China 2000-2009 (2000=100)

Year	**GDP Index**	**Per Capita Disposable Income Index**	**Residential House Price Index**	**Residential House Rental Index**
2000	100.00	100.00	100.00	100.00
2001	110.29	109.23	100.49	108.10
2002	121.03	122.66	105.98	110.26
2003	136.61	134.91	112.02	118.53
2004	160.81	150.03	122.55	121.14
2005	184.28	167.09	132.84	121.75
2006	213.16	187.25	141.34	123.45
2007	258.80	219.52	152.93	126.66
2008	302.42	251.29	163.79	129.45
2009	342.49	273.49	176.57	128.41

Data source: National Bureau of Statistics of China http://www.stats.gov.cn/

Empirical research by Chow *et al*. (2008) has confirmed the positive relationship between the housing market and GDP & disposable income. Also, a series of models adopted Peng, Tam and Yiu (2008) detect a two-way linkage between GDP and house price growth. Additionally, Li and Zhang (2010) show there is a positive relationship, using OLS regressions, between real house prices and inflation (consumer price index), and a reciprocal causation using the Granger Causality test between them as well.

3.2.1.2 Land Policy and Land Price

3.2.1.2.1 Land Policy

In the onrush of the whole market reforms and opening, the land policy has gone through a substantial revolution for the last 30 years. Land price, is an important determinant of house prices, and has continued to rise along with the booming of the housing market. Of course, the two are interrelated. The boom in house prices has been a factor on the price of land, which has fed into house prices and so on.

In recent years, despite land owned by the state, the innovations on the transfer of land use rights as well as development rights have led to the housing market flourishing. Deng (2005) elaborates on the development of land use rights in the last few years in China.[40] Liu (1998) describes the development of the real estate sector of the Chinese economy during the 1980s and 1990s. Chan (2003) exposes the compensation scandals in land acquisition in China. Furthermore, Wang (2010) discusses the process of taking cultivated farmland for city development and various formats for challenges on the land use rights transfer mechanism.

In order to provide food security for the country, the preservation of cultivated farmland is one of the major policy concerns in China. Therefore, the central government implements a series of standards and indicators to assure the percentage of farmland. For instance, 'The proposal of the eleventh 5-year plan stated by the Central Committee of the Communist Party of China' points out the cultivated land must remain at 1.8 billion acres until the end of 2010, so called '1.8 billion red line'. Tan and Beckman (2010) enumerate the three quotas in the land use provisions penetrating all five administrative levels (central, provincial, prefecture, municipal and township). 'The three limitations are: the maximum amount of land for construction during the planning period, the minimum amount of farmland within the planning period, and the maximum amount of converted farmland for construction over the planning period.'[41]

With the birth of Decree 11[42] (1997) and Decree 39[43] (1999), the State Council requests all levels of authorities (nation, province, city, county and township levels) to reinforce the

[40] For more details, see Table 2.1.
[41] Anderson, J. E., 2010. 'Housing, Taxation and Urban Development in China.'
[42] Circular of the Central Committee of the Communist Party of China and the General Office of the State Council on Further Strengthening Land Management and Practically Protecting Cultivated Land
[43] Circular of the General Office of the State Council on Strengthening Management of Transfer of Land and Strictly Banning Speculative Land Dealing

administration of farmland, as well as to severely punish illegal speculation in land purchase. The statements also require the government officials to redress the illegal land granting trade and return the construction land to farmland. In order to encourage the land market competition and make the land use rights more transparent, some new forms of granting land have emerged as the times require. Since 1st July 2002, 'Bidding Auction Listing Transferring State-owned Land Use Rights Provision' has been implemented by the Ministry of Land and Resources, which means land use rights are transferred via three new methods-invitations to tender, auction and listings (Deng *et al*., 2009). Over 2002 to 2004, the two systems, land agreement transferring and bidding auction listing transferring, coexisted simultaneously. According to Decree 71[44] (2004), by 31st August 2004, the marked boundary of land policy called '8.31 major limit of land granting', the old land agreement transferring has terminated and the new land transferring system was formally built up nationwide.

Thus far, land transferring has been entirely controlled by the state monopoly. Therefore, to a very great extent, these regulations drive the land price. It stands to reason that it is a simultaneous relationship between house prices and land price, both influence each other.

3.2.1.2.2 Land Price

As one of the principal determinants of high house prices in China, high land leasing fees to acquire land use rights account for the greatest proportion of residential housing construction costs for real estate developers. However, the high land granting fees apparently can be overcome by an even higher profit of the housing market afterwards. In the initial stage of the termination of the work unit-owned and state-owned housing allocation system and the initiation of the market-oriented housing market, property developers signed up for land use by granting contracts with local government officials with low nominal land use fees. Consequently, in order to acquire the privilege of land use and development rights, property developers tend to bribe the local authorities. The developers make every effort to build up a good relationship with local governments, and furthermore, to bribe the local officials (Gao, 2010). In fact, the black market operations eventually drove the land use cost to an extremely high level. The central government also realized there were such severe drawbacks, hence the new land regulation[45] for residential, industrial, or business uses was implemented in 2002, which requires the purchase of land use rights by invitations to tender, auction and listings.

[44] Circular of the Ministry of Land and Resources on Enforcement and Inspection of Carrying on the Tender to Sell the Operating Land Auction
[45] Bidding Auction Listing Transferring State-owned Land Use Rights Provision (1st July 2002)

For the purpose of 'complementary instructions', the new system contained fatal loopholes during the executive process by local administrative departments. In a quick response to the defects of the new system, by 2003-2004, the central administration reformulated more rigorous and transparent regulations to crack down the illegal transactions. To a great extent, these subsequent movements contributed to behind-the-scene land-versus-rights exchange trades in land use right transactions.

Even though, the accumulated research has indicated that the largest piece of housing construction cost was attributed to the land cost. Within the NPC[46] and CPPCC[47] of 2009, a conference speech of the All-China Federation of Industry & Commerce proclaimed the land cost takes up to 58.2% of the total building cost. Moreover, the report also appointed the biggest benefit taken by the local governments through transferring land use rights. Other similar studies have also shown that nearly half of housing construction fees is attributable to land leasing expenditure (Shao, 2005; Sun *et al*., 2006; Zhang and Peng, 2007). Based on a survey of 620 real estate projects nationwide in 2009, the Ministry of Land and Resources has issued another report, showing that the proportion of land leasing expenditure in total building costs was 23.2%. Taking 21 projects in Beijing as an example, land-cost/building-cost ratios ranged between 14.33% and 48.38%.

To empirically investigate the impact of land prices on Chinese house prices, Ding (2008), Deng, Ma and Chiang (2009), Fu (2007), and Yuan (2009) employed both land prices and rental prices into their regressions. And they all concluded that land prices have significantly affected real estate prices to different degrees. Particularly, Deng, Ma and Chiang (2009) added the land price using a dummy variable in their model, and found that the land price is an extremely crucial effect on house prices, especially after the new land policy implemented in July 2002. To briefly summarise, the land cost has become the biggest component of total real estate development costs.

3.2.1.3 Housing Monetary Policy

3.2.1.3.1 The Changes in Monetary Policy

Generally speaking, the monetary policy has impacted on the real estate market by two channels: money supply and interest rate (Ahearne *et al*., 2005; Lv *et al*., 2010). In comparing

[46] the National People's Congress
[47] Chinese People's Political Consultative Conference

the two tools, the interest rate has played a more significant role in the adjustment of housing market (Elbourne, 2008; Vargas-Silva, 2008; Del Negro & Otrok, 2005). The expansion of the money supply on both the investment sector and the consumption sector has promoted the booms of housing supply and housing consumption demand, and then exacerbated the constant increase of housing prices. To some extent, the easing of monetary policy can be one of the explanations for the house price increase. The soaring house prices far exceeds what is reasonable, when judged in international terms by the level of house price to income ratio, which most likely means a highly risky real estate bubble. As the pillar industry of the national economy, the collapse of the real estate industry could trigger the depression of the entire national economy through the bankruptcy of other relative industries, a large number of bad loans of the commercial banks, and the contraction of consumption. As we saw in the previous chapter, in order to restrain the excessive growth of property prices, a series of tight monetary policies have been implemented by the central government and the central bank, including continually upward adjustment of the statutory reserve ratio and benchmark deposit and lending interest rates, the cancellation of preferential interest rates for housing loans, the increase in minimal down payment for individual housing loans and the interest rate increase of individual housing fund loans (Yu and Yu, 2007).

3.2.1.3.2 The Effects of Monetary Policy on China's Housing Market

There exists a strange phenomenon in the Chinese housing market: the vacancy rate of commodity buildings is extremely high (Xie, 2010; Tang, 2006; and Jia, 2004); meanwhile, the house prices have stayed at a high level as well. One of the reasons has been the lower interest rate for real estate developers, which means the cost of credit for real estate developers is so small that suppliers hold the buildings without a sale in order to acquire more profit when house prices rise further. Furthermore, the speculators also drive up housew prices, such as '*Wenzhou Real Estate Corporation*'[48]. A series of rising interest rate policies have had a comprehensive effect on both the demand and supply sides of the housing market. In light of the study of Xie (2010), the effects of rising interest rates can be summarised as Box 3.1.

[48] 'Wenzhou Real Estate Corporation': speculators from Wenzhou, a rich and developed area in Zhejiang province, build up groups to acquire buildings for speculation in big cities, such as Beijing and Shanghai.

Box 3.1: The Effects of Rasing Interest Rate on China's Housing Market

I The Effects of Raising Interest Rates on the Demand Side

(1) Purchase as an owner-occupier

Purchase as an owner-occupier can also fall into two types: one is the demand for living, and the other one is for the improvement of living standards. The demand for living can be satisfied through either home purchase or rent of apartments. If the rental is comparatively lower than home purchase, individuals often choose to rent apartments instead of buying houses; and vice versa. The increase of interest rate has aggravated the interest burden of home purchasers. Potential home purchasers will rent houses instead of buying houses. The demand for the improvement of living conditions is for population with the affordability of home purchase, as long as the increase of interest rate is still within their expectation. If the house prices are stable during a period, the changes of interest rate will influence their disposal decision on their old small apartments. If the interest rate is still lower than the rental income, they will keep ownership and rent houses; by contrast, they will sell their old apartments in order to decrease holding cost of the existing apartments. The increase of interest rate, not only makes the burden of home loans heavier, but also implicates government's expectation of adjustment on real estate industry. In fact, the rational residents are willing to sell their old apartments, which increase the supply of housing and play a positive role on steady house prices.

(2) Hedgers for a store of money's value

There exists such a group of home purchasers, with middle-level incomes, lack of much professional knowledge on investment and without strong motivation to buying houses. They acquire apartments for two main reasons: on one hand, due to the sharp increase of house prices, people make sizable profit by home purchase; on the other hand, due to the higher inflation expectation and lower interest rate, they desire to store the value of their money by home purchase. These individuals are often lack of rational judgments on investment and the national macro-economy situation and not equipped with the powerful capacity of resisting risk. Thus they are always the major victims when the housing bubble breaks down. In a word, the increase of interest rate can adjust the inflation expectation as well as the house price increase expectation; also can enrich interest income of savings; in order to decrease housing demand of this group.

(3) Investors and speculators

The adjustment of real estate market is aim to strike the speculators, who gain exorbitant profit through frequently buying-selling houses. Increasing interest rate can increase the costs to speculators, and then push them out of the real estate market automatically. For general investors purchasing houses with their own capital, even if the interest rate rises, if no better investment opportunities emerge, they will maintain their house investment with an impressive rental income. While for speculators, their purpose is not to long-term hold apartments or to lease their houses; instead, they desire to gain extra profit by frequent buying-selling tricks. They trade on housing market by financial credit leverage of banks and concentrate their own capital on huge storage of buildings. Raising interest rate increases both purchase cost and opportunity cost of housing storage. Therefore, the appropriate interest rate level can reduce the demand of speculators, as well as encourage speculators to sell their vacancy apartments. The decrease of speculation demand and the increase of (second) housing supply should induce a significant jump down of real estate prices.

II The Effects of Raising Interest Rate on the Supply Side

It contributes to so-called 'exuberant demand' for houses that speculators hold large sources of apartments without sale; meanwhile, property developers create so-called 'short supply' via storing land and holding buildings. Developers get the instruction and development loans from banks with very low interest rate, which makes the opportunity cost quite low to store land and buildings. Raising interest rate can push up their opportunity cost, especially for housing industry with excessively high debt ratio and financial leverage. The interest rate adjustments have deteriorated the financial burden of real estate enterprise, and increase the construction and development costs as well.

To conclude, there are three aspects of impact of interest rate changes on real estate industry in the short run: firstly, it implicates a macro-control signal from the central government, thereby cool down the consumption expectation of house prices; secondly, it can increase the money income of depositors, while cause heaver interest rate burden of creditors, thus to restrain housing demand of investors and speculators; thirdly, it can increase the opportunity cost of storing land and buildings for investors and speculators. The interest rate adjustments make a dynamic equilibrium between demand and supply sides by market-oriented 'invisible hand' to change cost-yield curves of home purchasers and sellers.

Zeng (2008) tested the transmission procedure of monetary policy on house price dynamics and concluded that the money supply had a negative impact on the house prices but the interest rate had a positive shock on house prices, which reflected that monetary policy has a positive influence on house prices. Generally, the interest rate, as the major monetary instrument, played a more important role than the money supply in the Chinese housing market. In addition, Zhao (2010) improved upon Zeng (2008)'s research and illustrated the dynamic influences of both demand shocks, supply shocks and monetary shocks on China's real estate price fluctuations. Another Chinese scholar Duan (2008) found that, the contractionary monetary policies have negative effects on real estate prices, while the expansionary monetary policies drive up real estate prices. Additionally, compared with interest rate policies, house prices exhibit a higher sensitivity to credit based monetary policies.

However, the effect of monetary policy on Chinese house prices is not a consensus issue. Some researchers fail to detect a significant impact of interest rates on real estate prices, such as Fu (2007), Deng, Ma and Chiang (2009). Specifically, Dong, Duan and Ming (2010) who claimed that the effect of the nominal interest rate was not significant, while the effect of the real interest rate was.

3.2.1.4 Urbanization and Immigration (Household Registration System-'*Hukou*')

Many scholars have explored the possible effects of demographic factors on the housing market. More specifically, demographic variables can influence house prices via both the demand and supply sides of the housing market. Some house price models are estimated including demographic factors, such as immigration, urbanization and the population's ageing structure.

China's rapid urbanization process, generated by history's largest flow of rural-to-urban migration in the world, has led to the rapid increase in the urban population (Chan and Zhang, 1999). Since housing is an essential requirement for each household, the demand for housing is usually not elastic, but inelastic, in the Chinese social environment (Shaw, 1997); which implies that the expansion of the urban population would induce a heavy demand for dwellings without any substitutes. Compared with other countries, China differs, to a certain extent, in migration and urbanization patterns as a result of its unique Household Registration System (*Hukou* system) and huge population base. Most rural migrant workers in cities are unofficial city dwellers without a change of Hukou, who have not been included in calculation of urban population.

What impact do these immigration waves with official and unofficial workers have on the Chinese housing market and housing price dynamics? Do the massive rural-urban migrants drive up the price of commodity buildings in urban areas? Some existing studies have answered the above questions mainly from a macro-aspect viewpoint of the Chinese housing system, such as the housing polices (Wang and Murie, 1999a&1999b), housing consumption (Li, 2007), or an assessment of Chinese housing reform (Tong and Hays, 1996). Some scholars have also analysed the institutional factors-as the unique determinants-affecting the Chinese housing consumption and residential crowding (Huang and Clark, 2002; Huang, 2004).

But there has not been a great deal of empirical analysis on the impact of urbanization and migration factors on Chinese urban housing market growth. Further studies have contributed to the role of urbanization and rural-urban migration in affecting housing price dynamics in China (Chen *et al.*, 2010; Zeng, 2010). Chen *et al.* (2010, pp. 1) analyse 'the changes over time in house prices in each Chinese province and examine empirically the determinants of urban house prices at national and regional levels using time-series and cross-sectional data'. Their analysis suggested the urban household income and the urbanization level were significant factors driving up Chinese house prices, whilst the impact of floating workers and the supply side of urban houses were insignificant. Zeng (2010) constructed a straightforward linear equation to estimate the effects of urbanization on Chinese house prices. His model only included three variables: house prices, the urbanization level and inflation rate. His estimation suggested that, under the condition of inflation effects, urbanization played a significant role in determining the real estate price, which suggests that the urbanization dynamic should be considerable in my study. In addition, some recent quantitative analysis on the Chinese urban housing market has focused on exploring housing consumption and residential mobility in the big cities of China (Li, 2000&2003; Lau and Li, 2006).

3.2.1.5 Cultural Effects and Investment Requirements (speculation)

'As in many other East Asian countries, demographic changes, rising income and in particular housing aspirations, all contributed to inflation of housing prices in China' (Renaud *et al.*, 1997). Real estate property is enormously important in China due to people's belief in the traditional idea of 'land is wealth' (Chien, 2010). The cultural impact can be another reasonable explanation of this preference for household ownership. Chinese people, especially the young, tend to regard owning real estate property as a precondition for creating a family. In contrast, it is not a popular wish to rent a house for individuals with a stable job. Chinese parents are always willing to dedicate all their savings to acquire real estate property for the marriages of their sons or daughters. As a consequence, 'income and saving from two generations and three families (bride's parents, groom's parents, and the young couple themselves) all combine to purchase a single apartment, which drives the already high house price to an even higher level' (Gao, 2010).

In addition to the cultural impact, other factors also contribute to the high house prices and high house price to income ratios, such as the demand for long-run investment, limited investment channels, and even speculation. Notoriously, Chinese people are so conservative and old-fashioned that China has become a country with the highest savings ratio in the world. It was reported that the domestic savings rate of 2005 was as high as 51% in China, compared with 19.7%-the global average level (Sina Finance)[49].

One of the major reasons for the highest savings ratio is that there is a lack of good channels and opportunities for Chinese citizens to allow their money to appreciate (Qi, 2000; Yu, 2003; Shi and Zhu, 2004; He and Cao, 2005; Kuijs, 2005). Unlike the financial markets in developed countries, the Chinese financial market is far from a fully complete competitive market. Therefore, the classes of financial products and financial derivatives are too few to meet people's needs. Also, due to market imperfections on regulations, it is not easy for people to invest in most financial instruments (Kuijs, 2005). The severe turbulence of the stock market has triggered large losses for many civilians. Take the security market as an example, it has always been suffering large fluctuations since it was established in the early 1990s (SSE[50] in 1991 and SZSE[51] in 1992). The Shanghai Composite Index remained at under 2000 points before 2000. While it reached up to around 2100 points in 2001, then dropped down to between 1300 and 1700 points. In 2005, the market continuously fell to under 1100 points. After the lowest part, the stock market has increased to the historical highest level of 6057 points on the 17th October 2007, which was the beginning of the global financial crisis. Following the boom, the Index sharply dropped down to about 1800 points in 2008, and stayed at 2700-3300 points in recent years.

Furthermore, people know little about other advanced financial products or derivatives either.

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[49] Sina Finance, 14th March 2006, Available from: http://finance.sina.com.cn/xiaofei/consume/20060314/11512415695.shtml [Accessed 11th July 2011]
[50] Shanghai Stock Exchange
[51] Shenzhen Stock Exchange

By contrast, it is a good choice for individuals to invest savings in the Chinese housing market (Gao and Leng, 2010). Since for the last three decades, house prices in China have kept a sustainable increase, which means investing in real estate is a more desired and insurable approach to making profits. Moreover, investment in property not only maintains capital value, but allows speculation in the property market (Gao, 2010). Many high income families attempted to acquire excess profits by purchase of a second or even more properties. Conversely, property market speculation and manipulation significantly drove the house prices up.

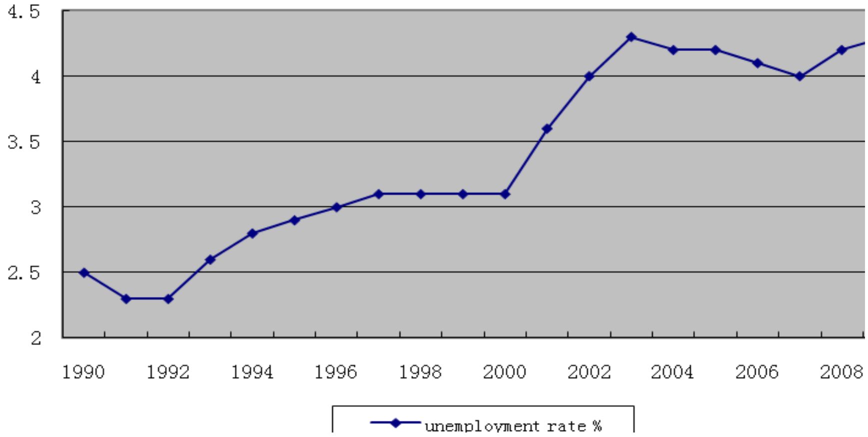
3.2.1.6 Other Relative Determinants of House Prices

Except for the determinants mentioned above, such as economic factors (GDP and disposable income), policy factors (land policy and monetary policy), demographic factors (immigration, Hukou system and population age structure), cultural factors and investment requirements, there are many other factors which affect China's real estate market and house prices: unemployment, housing tax policy and stock market, etc.

3.2.1.6.1 Unemployment

Some specialists have interpreted the relationship between unemployment and house prices. In reality, the impacts of unemployment on the housing market are different in different areas. Deng, Ma and Chiang (2009) have included unemployment as an explanatory variable in models estimating house prices. They interpreted a lagged significant negative influence of the unemployment rate on Chinese real estate prices through a Panel VAR model. However, Liu and Shen (2005) have claimed that the fluctuation of house prices in China is not well explained by the unemployment rate. Their explanation is covering the study period between 1986 and 2002 when the government and state-owned enterprises (SOE) provided most residential housing, regardless of people's actual purchasing power. Therefore, there are different conclusions between these two research groups.

The different findings are probably due to the different study periods or different estimation models. While from the Figure 3.1, it can be seen that the nationwide unemployment rate has been going through a consistent increase in China from 1990 to 2009. But as mentioned before, Chinese house prices have also been increasing over recent years. In the following chapters, my empirical work will construct the equations including the unemployment variable, and we will see how the unemployment rate fluctuation impacts on the house prices.



(Data Source: National Bureau of Statistics of China http://www.stats.gov.cn/)

Figure 3.1: The Nationwide Unemployment Rate in China, 1990-2009

3.2.1.6.2 Housing and Land Tax Policy

Taxation is one of the essential instruments which governments use to regulate and control the real estate market. Meen (1998, 2001) analyses the effects of housing and land taxes on house prices. Many theoretical studies indicate that real estate tax policy can induce the changes of frequency of housing transaction, transaction volume and bargain prices. Most developed countries and areas in the world have levied housing and land taxation with a mature tax policy system, which makes real estate tax not only to be an effective source of local government finance but also a tool to adjust real the estate market effectively (Du, 2009). Housing and land taxes have contributed to reducing the real estate speculation by increasing the cost of holding real estate, and thus controlling the growth of house prices efficiently. Noord (2005), Lopez-Garcia (2004), and Lang & Jian (2004) summarise similar conclusion through a number of empirical researches on the relationship between real estate taxes and house prices. For the Chinese housing market, many scholars have approached some discussion on this topic. Yang and Xu (2007) suggest that, due to the less demand elasticity of home purchasers, real estate taxes can control house prices from the view of cost-benefit analysis. Wang (2004), Chen and Zong (2004) all demonstrate the influence of real estate taxes on the housing market with reducing expectations and the revenue of real estate speculators. In addition, Yi (2006) believes the adjustment of housing and land taxes is the most convenient, straightforward and efficient instrument to regulate the real estate market;

since with high real estate taxes, speculators with many dwellings have to sell their vacant apartments to reduce the holding costs.

3.2.1.6.3 Stock Market

The determinants that affect the house price dynamics are of interest to governments, policymakers, urban planners, real estate developers, housing scholars and financial institutions as well as most householders. In most countries and areas around the world, many researchers recognise that there is a mutual relationship between the stock market and real estate market (Quan and Titman, 1999; Tse, 2001; Chen, 2001; Green, 2002; Kapopoulos and Siokis, 2005); therefore, the equity price has become another essential factor in determining house price changes.

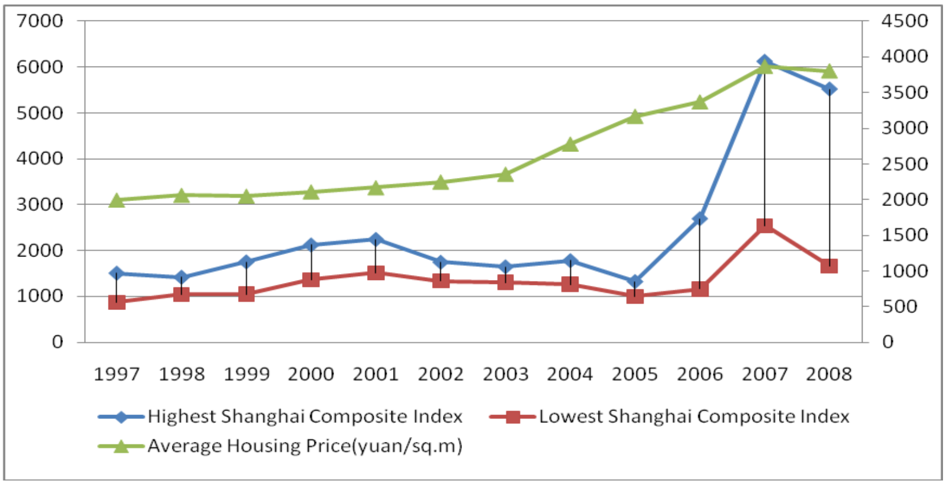
In China, there is evidence that there exists a simultaneous relationship between the real estate market and the capital markets within the entire macro-economy. Dong (2009) proclaims that house price dynamics must co-move with the changes of equity prices. He shows that if stock market returns increase, real estate prices must increase; conversely, if stock prices slump sharply, house prices must be more resistant in a bear market. Kuang and Zhao (2010) draw some more specific conclusions about the relationship of the two asset prices by theoretical analysis and empirical verification:

(1) Their theoretical model indicates the current stock price has a positive relationship with the current house price but a negative relationship with real estate prices in the next time period. Additionally, the empirical results also verify this proposition.

(2) The empirical results show a strong interaction between the two asset prices, but the mutual response is asymmetric. The effect of the real estate market on the stock market seems to be more significant than the impact of stock market on housing market. Their interaction has been manifested in four general perspectives: firstly, the current house prices move together with stock prices in the same direction, but the changes of house prices in the next time period moves in the opposite direction to the current stock prices. Secondly the fluctuations of house rental prices have no significant influence on either stock prices or real estate prices. Thirdly, compared with the Western area of china, the growth rates of both asset prices are more excessive in the Eastern part and Middle part, which implies that geographic factors also have an impact on the two asset prices. Finally the house prices show a significant serial correlation, but stock prices exhibit stochastic changes.

(3) The regression results of the stock price equations indicate that there is a co-movement in the same direction of the stock risk premium, stock turnover rate, stock equity, capital growth and stock prices. The regression results of house price functions indicate that the increase of the lagged development cost can drive up real estate prices, and the increased rate of house prices is more significant in urban areas with higher economic growth.

To sum up, even though China's stock market has a mutual interaction with China's housing market, looking at the whole picture, we can see that huge fluctuations in the stock market over the last two decades in China would not substantially stop the sustained house price increase during these years. Figure 3.2 demonstrates the nationwide average commercial house prices over 1997-2008 and the highest & lowest point of Shanghai Composite Index in SSE market during the same period. This figure cannot tell the significant effects of the stock market on the house prices



(Data Source: National Bureau of Statistics of China http://www.stats.gov.cn/)

Figure 3.2: Shanghai Composite Index and Average Housing Price, 1997-2008

3.2.1.7 Summary of the Impact Factors on Chinese House Prices

Taken together, Figure 3.3 shows the correlation linkages between Chinese house prices and these factors. Chinese house prices have been affected by various determinants. Generally, these factors can be divided into two types: demand side and supply side.

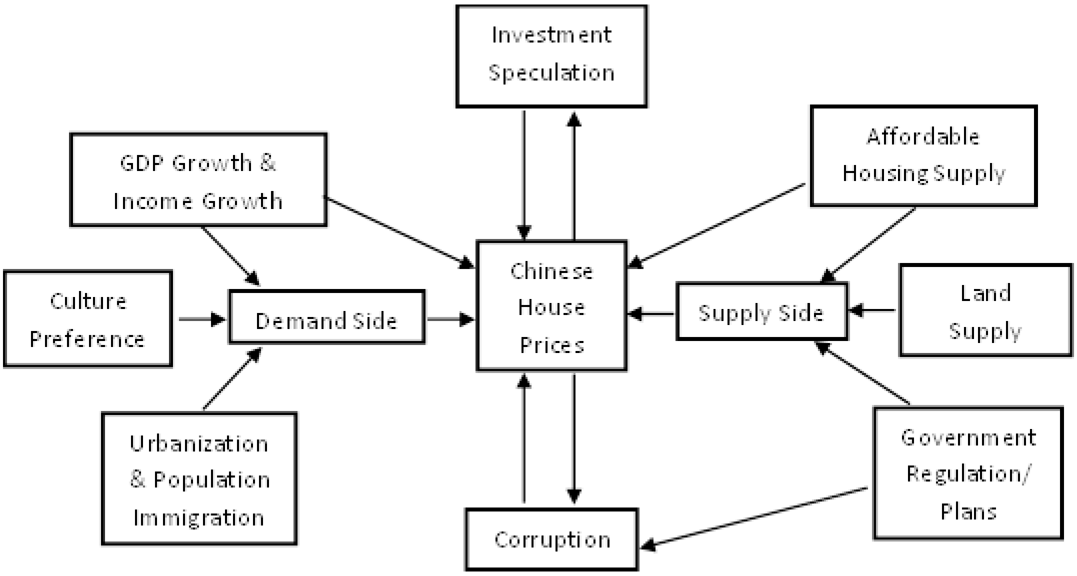


Figure 3.3: The Correlation Framework of Chinese House Prices and Other Factors

From the demand side, the rapid growth of GDP and household income has become the major driver of house price increase (Yiu, 2010; Stephens, 2010). Furthermore, the dramatic urbanization process and population immigration from rural to urban areas have also contributed to the rise in house prices (Hao, Sliuzas and Geertman, 2011; Zhao, 2011). In addition, due to the Chinese traditional culture, the preference of purchase housing is a common perspective for most Chinese people, since they believe ‘land and housing is wealth’. Therefore, the cultural preference has become another special reason to the house price growth in China (Chien, 2010; Gao, 2010).

From the supply side, many studies shed light on the issue that the land cost has become the biggest part of the total real estate development cost since the implementation of the new ‘Bidding Auction Listing Transferring State-owned Land Use Rights Provision’ with the Chinese housing reform (Leung and Chen, 2006; Wu, Gyourko, and Deng, 2010; Leung, Chow, Yiu and Tam; 2010; Zhao, 2011). As a result of the new land policy, the land transfer prices have been steered by the interest conflict between the central authority and local governments; therefore, the insider trading and black market operation has further driven up the Chinese house prices (Zhu, 2000; Li, Chiang and Choy, 2011). Meanwhile, another chief factor of the house prices has been attributed to the insufficiency of affordable housing supply (Gao 2010; Deng, Shen and Wang, 2011).

Apart from these fundamental variables which determine Chinese house prices, the financial market also has played an important role in the Chinese housing market, mainly through the interest rate and the housing mortgage loan (Deng *et al*., 2005; Zhu, 2006; Stephens, 2010; Deng, Shen and Wang, 2011). Consequently, the investment speculations and the Chinese house prices have mutually combined to jointly increase (Huang and Clark, 2002; Lau and Li, 2006; Mak, Choy and Ho, 2007; Gao, 2010).

In summary, these determinants from different sectors have played a profound role in the development process of the Chinese housing market. They have contributed to the rapid growth of Chinese house prices with varying degrees. Vice versa, the house price increases have also provoked the further development of some variables. In the existing research, a number of scholars have done plenty of good theoretical and empirical studies on the Chinese housing market. The next part of this chapter will conclude previous researcher's models and focus on their empirical analysis of Chinese house prices.

3.2.2 Methodologies and Models of Chinese House Prices

In a general view of the existing literature, several representative models have been employed in modelling Chinese house prices, for example, basic Ordinary Least Squares (OLS) Model, Vector Error Correction Model (VECM), and (Structural) Vector Autoregression Model (VAR/SVAR). Although the VAR is the most common regression form among the above models, a prevalent advanced method, Generalised Method of Moments (GMM) estimation, has been implemented most recently, especially in the panel data case. We will discuss each method or model individually and explore their typical traits.

3.2.2.1 Basic OLS Model

Starting with the most basic linear model on Chinese house prices, a number of scholars use the OLS model to study the driving factors of real estate prices (Cheng, Guo and Wu, 2011; Gao and Leng, 2010; Leung *et al.*, 2010; Li and Zhang, 2010; Zeng, 2010). An example of an OLS model using time-series data is in Zeng (2010) in studying the impact of urbanization on house prices. His model only included three variables: house prices (*HP*), the urbanization level (*CSH*) and inflation rate (*CPI*): $HP_t = \beta_0 + \beta_1 CSH_t + \beta_2 CPI_t + \mu_t$. While Leung *et al.* (2010) set a panel OLS model with quarterly data (over 2000Q3 to 2007Q4) across four major cities (Beijing, Shanghai, Tianjin, and Chongqing):

$GP_{it} = \varphi[\gamma_1 GR_{ir} + \gamma_2 GWAGE_{ir} + \gamma_3 DU_{ir}] + (1+\varphi)GP_{it-1}$, where *GP* is the growth rate of the overall property price index, *GR* is the growth rate of the real rental, *GWAGE* is the growth rate of household real disposal income, and *DU* is the annual difference of the real lending rate for housing loans as a measure of user cost of homeownership. The lag of *GP* indicates the dynamic nature of their model.

Furthermore, others (Dong, Guan and Ming, 2010; Wu and Zeng, 2010) adopt the logarithm OLS model to eliminate the heteroscedasticity and autocorrelation, by taking the logarithmic format of variables. For instance, Dong, Guan and Ming (2010) used 1999-2006 province-level panel data to analyse the dynamic determinants in the Chinese housing market. Their logarithmic OLS estimation is expressed as:

$$\begin{aligned} &\log(priceRE_{it}) = \beta_1 \log(priceLand_{it}) + \beta_2 \log(pcgdp_{it}) \\ &+ \beta_3 popden_{it} + \beta_4 revenue_{it} + \beta_5 IR_t + \beta_6 REER_t + \varepsilon_{it} \end{aligned}$$

Their empirical evidence implied that the main driver of the house price (*priceRE*) came from the demand side (*popden* and *pcgdp*) of the Chinese housing market, and that local governments (*revenue*) also played an important role in determining real estate prices. By contrast, the effects of supply side (*priceLand*) and monetary policies (*IR* and *REER*) had less significant impacts on real estate prices.

Also, with the province-level panel data over the period 1999 to 2008, Wu and Zeng (2010) suggested that the drivers of the house prices in China fell into two groups: supply side and demand side, in building up the logarithmic OLS equation:

$$\begin{aligned} &PRE = \beta_0 + \beta_1 \ln(SRE) + \beta_2 \ln(LPI) + \beta_3 \ln(AMPI) + \beta_4 \ln(IR) \\ &+ \beta_5 \ln(TP) + \beta_6 \ln(TI) + \beta_7 \ln(GGDP) + \beta_8 \ln(RI) + \beta_9 \ln(M_2) + \varepsilon \end{aligned}$$

Interestingly, they concluded Chinese real estate prices (*PRE*) have a positive correlation with the demand side factor of urban investment (*TI*) and the supply side factor of six-month to one-year loan interest rate (*IR*); while there is no significant influence of either the demand factors of the supply of commodity houses (*SRE*), land price index (*LPI*), building material price index (*AMPI*), nor the demand factors of urban population (*TP*), and the GDP growth rate (*GGDP*), urban householder disposable income (*RI*), the liquidity index (M_2).

3.2.2.2 VECM Model

Taking the primary OLS model, researchers usually test for cointegration among dependent variables and explanatory variables, to explore a latent long-run relationship between two series (Wooldridge, 2012, Chapter 18, pp. 651-652). Hence, for the existance of cointegration between house prices and other independent variables, Ding (2008), Fu (2007), Li (2010) and Yuan (2009) developed the VECM model to study the Chinese real estate prices. Fu (2007) and Yuan (2009) employed a VECM model. Specifically, Fu (2007) and Yuan (2009) specified their VECM models as following respectively,

$$\Delta \log p_t = \beta_0 + \beta_1 \Delta \log S_t + \beta_2 \Delta \log Pop_t + \beta_3 \Delta \log R_t + \beta_4 \Delta \log Cost_t + \beta_5 \Delta I + \alpha ecm_{t-1} + \varepsilon_t$$

$$\begin{aligned} &\Delta \ln HP_t = \beta_0 + \beta_1 \Delta \ln HP_{t-1} + \beta_2 \Delta \ln DGDP_{t-1} + \beta_3 \Delta \ln LP_{t-1} \\ &+ \beta_4 \Delta \ln Sloan_{t-1} + \beta_5 \Delta \ln Dloan_{t-1} + \alpha ecm_{t-1} + \varepsilon_{t-1} \end{aligned}$$

where *HP* is house price, *S* is householder savings, *Pop* is population factor, *R* is rental price, *C* is construction cost, *I* is interest rate, *DGDP* is disposable income, *LP* is resident land purchased price, *Sloan* is real estate development loans for housing supplier, *Dloan* is housing consumption loans for housing consumers, and *ecm* is the error correction term. Fu (2007)'s study suggested that the demand factors, population and savings, had a significant effect on real estate price changes in both the short and long run; while the effects of monetary policy, through interest rate adjustment, failed to efficiently affect house prices as expected. Yuan (2009)'s main conclusions can be represented as: to a great extent, the rapid growth of China's real estate price was a bubble phenomenon under the pressure of excessive financial support, land price increase and speculative investment activities.

Li (2010) used the VECM model in the panel data estimation as well, for Chinese cities that passed the cointegration test:

$$\begin{aligned} &\Delta \ln p_{i,t} = c + c_1 \Delta \ln r_{i,t} + c_2 \Delta \ln r_{i,t-1} + c_3 \Delta \ln r_{i,t-2} \\ &+ c_4 \Delta \ln p_{i,t-1} + c_5 \Delta \ln p_{i,t-2} + c_6 \Delta \ln p_{i,t-3} + c_7 \varepsilon_{i,t-1} \end{aligned}$$

Her studies mainly discuss the effects of the previous house prices (*p*) and interest rates (*i*) on the current house prices, by including the lag 1, 2, and 3 of two variables. She advocated that, in the short run, the effects of the interest rate is significant in the eastern region but not in the western region. In the middle region of China, the interest rate has a more significant relationship with house prices in the long run.

3.2.2.3 VAR/SVAR Model

When considering the endogeneity problem of the house price models, the VAR model can be implied as a large-scale simultaneous equations structural model (Brooks, 2008, Chapter 6). The VAR model is popular in modelling the housing market with current researchers in China (Deng, Ma and Chiang, 2009; Duan, 2008; Liu, 2010; Zeng, 2008; Zhou, 2010). For example, Liu (2010) explored the mutual reactions between household savings and house prices with the VAR, and Zhou (2010) adopted the VAR to investigate the relationship between the total retail sales of consumer goods and house prices with 3 lags of duration.

A panel VAR model was developed by Deng, Ma and Chiang (2009) to examine the dynamic impact of fundamental elements on Chinese house prices. Their panel VAR equation is written as:

$$P_{it} = \beta_o + \beta_i^e \sum_{i=0}^{n} X_{i,t-i} + \varepsilon_{it}$$

They suggested that, the main fundamental explanatory factors explaining house price variation are household disposable income (Y_{it}), land prices (L_{it}), construction cost (C_{it}), new-building supply (NB_{it}), housing units sold (HS_{it}), unemployment (UR_{it}) and stock market return (SR_{it}). Sometimes lagged values are significant. But the effects of the rent (R_{it}), interest rates (INT_{it}) and population growth (POP_{it}) are not significant.

In order to specifically test the importance of land prices, they included a dummy variable for land elements, especially after 2002:

$$P_{it} = \beta_o + \beta_1 L_{it} d_1 + \beta_i^e \sum_{i=0}^{n} X_{i,t-i} + \varepsilon_{it}$$

d_1= 1 if the land is granted after 2002, that is, when the land use rights are granted through the new land policy; otherwise, d_1= 0. Their findings strongly supported the significance of the dummy variable, which indicated the new land policy has played a profound role in the housing market.

Further, Zeng (2008) built a 7-variable Structural VAR (SVAR) model to detect the transmission procedure of monetary policy via house prices, embodying a house price index (*HP*), GDP (*GDP*), CPI (C*PI*), total retail sales of consumer goods (*CON*), total fixed asset investment (*IN*), nominal interest rate (*IR*), and the money supply (*MS*) presented by M_2.

$$\begin{bmatrix} e_{CON} \\ e_{IR} \\ e_{MS} \\ e_{IN} \\ e_{HP} \\ e_{P} \\ e_{GDP} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} \\ a_{21} & 1 & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ a_{41} & a_{42} & a_{43} & 1 & a_{45} & a_{46} & a_{47} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & a_{57} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & a_{67} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} u_{CON} \\ u_{IR} \\ u_{MS} \\ u_{IN} \\ u_{HP} \\ u_{P} \\ u_{GDP} \end{bmatrix}$$

where *e* measured the structural impacts and *u* were error terms. In order to keep the independence of random shocks and calculate the dynamic response of system to the shocks, the SVAR model needs to add certain constraints to the VAR model based on the economic theories. Hence, he made a few hypotheses on the short-run shocks:

(1) except for the price level, other shocks have no instant impact on consumption, thus $a_{12} = a_{13} = a_{14} = a_{15} = a_{17} = 0$;

(2) since the interest rate is an exogenous variable controlled by the central bank, the interest rate has no response to other shocks, which means $a_{21} = a_{23} = a_{24} = a_{25} = a_{26} = a_{27} = 0$;

(3) except for GDP, other shocks can affect the supply of money immediately, so $a_{37} = 0$;

(4) consumption, money supply and GDP have no effect on investment instantly, therefore $a_{41} = a_{43} = a_{47} = 0$;

(5) except for the interest rate and money supply, other shocks have no instant influence on house prices, thus $a_{51} = a_{54} = a_{56} = a_{57} = 0$;

(6) the price level has no effect on interest rate and GDP immediately, so $a_{62} = a_{67} = 0$;

(7) except for consumption and investment, GDP has no response to other shocks, which means $a_{72} = a_{73} = a_{75} = a_{76} = 0$.

His assumptions would in themselves help us understand the Chinese housing market. He concluded that the money supply had a negative shock on the house prices but the interest rate had a positive shock, which reflected that the monetary policy changes result in a positive adjustment to house prices. Also, the housing market had a profound influence on the macro-economy. More specifically, there was a significant wealth effect of the real estate prices on social consumption as well as on investment. In addition, the real estate prices impacted upon GDP directly by industry driving effects; meanwhile, it is also one of the major forces on inflation (price level). Overall, he suggested that the interest rate, as the major monetary instrument, played a more important role than the money supply in the Chinese housing market.

The VAR model could be further extended to the case of the VECM where the model includes first difference terms and cointegrating relationships; meanwhile, it is usually followed by impulse response and variance decomposition analysis (Brooks, 2008).

3.2.2.4 GMM Estimation

In the case of panel data, another broadly adopted method in modelling Chinese house prices is GMM estimation. Peng, Tam and Yiu (2008) induced the GMM estimator to obtain efficient parameters of β and ρ_j into their first-differenced dynamic panel equation:

$$\Delta Y_{it} = \sum_{j=1}^{p} \rho_j \Delta Y_{it-j} + \Delta X'_{it} \beta + \Delta \varepsilon_{it}$$

where Y denotes property price growth; $\boldsymbol{X}$ denotes the independent variable matrix (GDP, fixed asset investment, real estate investment, retail sales and bank credit). Moreover, they introduced an additional explanatory variable as the dummy variable into the estimation: taking a value of one for coastal provinces and cities, and zero for the rest of the sample. Cui (2009)'s function has been estimated by the GMM method as well:

$$\Delta price_{it} = \alpha_1 + \beta_1 \Delta price_{it}(-p) + \beta_2 \Delta popul_{it} + \beta_3 \Delta inc_{it} + \beta_4 \Delta cpi_{it} + \beta_5 \Delta comp_{it} + \beta_6 r_t + \varepsilon_{it}$$

where (–*p*) is the lagged indicator of real estate price (*price*), *popul* is population, *inc* is per capital disposable income, *cpi* is price level, *comp* is house space completed, and *r* is interest rate.

Both the above contributions have used the difference GMM estimators. However, they have neither clearly explained the necessity of GMM estimation nor systematically illustrated the procedures generating the GMM estimator. Moreover, due to the sensitivity of GMM regression, the existing studies have not applied the robustness checks either.

3.2.3 Summary of Literature Review

Comparing to the rest of the world literature with that on China, despite the relative young age of the Chinese housing market and the greater degree of government control, there are substantial similarities in the impacts of the different variables, such as in the importance of the housing market as a source of taxation revenue and even in government controls. But one problem affecting the studies on China has been a lack of data.

To sum up, many scholars have contributed to the studies of the Chinese housing market. Their research has mostly covered the major fundamental aspects of explanatory variables affecting China's real estate prices, which can be divided into two sectors—demand sector and supply sector. From the demand side, previous research provides sufficient evidences that the growth of some fundamental variables, such as GDP, income, population immigration with the rapid urbanization, housing consumption and housing units sold, have become the dominative factors of the upswing. Besides, the culture preference of 'land and housing is wealth' also played an important role in China's housing market. From the supply side, because of the rise of land cost, land supply has most likely become one of the most powerful forces to push up the China's housing market. Investment and rent prices might play an important role as well. Apart from these fundamental dynamics, government intervention has a profound influence on the Chinese housing market through the policy decision-making channels, such as housing policy, land policy and monetary policy. However the conclusions in analysing the Chinese real estate prices are still controversial. There are many reasons for these inconsistent positions, such as differences in the data, methodologies and models.

Some common methods and models have been employed in analysing the Chinese housing market, that include basic linear regressions, such as OLS and log-linear OLS models, and more advanced estimations, such as VECM model, VAR or SVAR models and GMM estimation. VAR models are most broadly preferred by Chinese scholars in modelling panel-data house prices. As Brooks (2008) claimed, users do not need to specify which variables are endogenous or exogenous, as all are treated as endogenous. In practice, this restriction leaves the researchers with a great deal of discretion concerning how to classify the variables. But the researchers also have the option of using the SVAR, in order to impose some structure on a VAR. Also, VAR models are more flexible by allowing the value of a variable to depend on more than just its own lags or combinations of white noise terms. Furthermore, VARs are acknowledged as a powerful device for forecasting (Brooks, 2008, Chapter 6, pp. 292; Wooldridge, 2012, Chapter 18, pp. 657).

Nonetheless, Brooks (2008) also enumerated the drawbacks and limitations of VAR models: (1) the lack of theoretical information about the relationships between the variables, that makes VARs less amenable to theoretical analysis and therefore to policy prescriptions; (2) the difficulty of determining the appropriate lag lengths; (3) too many parameters, especially when there are a number of variables; (4) the requirement of all components to be stationary, that is why most VAR users apply the first difference format of variables. Specifically, the degrees of freedom will decline a lot in panel data models of Chinese house prices. Since many fundamental determinants are involved; and the time dimension is quite limited (accurate data is only available from 1999 after the new housing system), compared with the cross-section dimension (at the province level—31 province). Consequently, this allows us to explore more applicable estimations for the Chinese housing market.

It is also worth mentioning that, the Exponential Generalized Autoregressive Conditional Heteroscedasticity-in-Mean (EGARCH-M) model (Morley and Thomas, 2011) and Conditionally Heteroskedastistic-in-mean (CGARCH–M) model (Karoglou, Morley and Thomas, 2013) are also used to examine whether house prices exhibit some properties associated with assets such as equities. Since these studies focus more on the financial features of house prices rather than the macroeconomic determinants, we will leave this issue out of our research.

This literature review will inform the rest of this chapter. This literature, focused on China, is a young literature partly because the Chinese housing market with a market focus this is a relatively new phenomenon. But this newness has meant that there has been relatively little data to work with and crucially that data excludes the period since the 2008 crash. We have more data which covers the period since the crash. In a word, the empirical analysis is based on the previous studies of predecessors in this literature, but with more innovative approaches and of course more up to date and extensive data. One of the key questions we will be asking is whether the conclusions of the previous literature are still applicable and secondly whether there are any signs of the Chinese housing market moving closer to that in other market economies.

3.3 Methodology

3.3.1 Basic Model

One of the difficulties for house price models is that a single equation is unlikely to capture the full determinants of house prices. The most basic theory on the dynamics of house prices is a supply-demand approach (Cameron, Muellbauer and Murphy, 2006; Deng, Ma and Chiang, 2009; Fu, 2007; Jud and Winkler, 2002). In the Chinese housing market, we will estimate the dynamics of real house prices over 30 provinces/cities across China from 1999 to 2009 by construction of an equilibrium equation for the demand-supply model[52]. In line with the panel data literature, *i* denotes the area dimension and *t* denotes the time dimension. The demand equation for house prices is given by:

$$Q_{i,t}^{D} = D(HP_{i,t}, Y_{i,t}, P_{i,t}, UR_{i,t}, I_{i,t}, HC_{i,t}, D_{i,t}, u_{i,t}) \tag{3.1}$$

where $HP_{i,t}$ = real house price; $Y_{i,t}$ = real disposable income; $P_{i,t}$ = urban population proportion; $UR_{i,t}$ = unemployment rate in urban areas; $I_{i,t}$ = statutory reserve ratio; $HC_{i,t}$ = real housing consumption; $D_{i,t}$ = housing demand, which is indicated by floor space sold; and $u_{i,t}$ = random error term.

The supply equation for house prices can be expressed as:

$$Q_{i,t}^{S} = S(HP_{i,t}, C_{i,t}, T_{i,t}, INV_{i,t}, S_{i,t}, e_{i,t}) \tag{3.2}$$

where $HP_{i,t}$ = real house price; $C_{i,t}$ = real construction cost; $T_{i,t}$ = real urban land use tax; $INV_{i,t}$ = real investment completed; $S_{i,t}$ = housing supply, which is denoted by floor space of building completed; and $e_{i,t}$ = random error term.

Except for the urban population proportion, unemployment rate and statutory reserve ratio, all of other variables are defined in logarithms.

Then, let $Q_{i,t}^{D} = Q_{i,t}^{S}$, we get the house price model as following:

[52] The parts of this chapter have been presented in the *'2nd International Institute of Social and Economic Sciences (IISES) International Academic Conference'*, the *'Finance and Economics Conference 2012'*, and the *'2012 Shanghai International Conference on Social Science (SICSS)'*.
This chapter is also a working paper.

$$HP_{i,t} = f(Y_{i,t}, P_{i,t}, UR_{i,t}, I_{i,t}, HC_{i,t}, DS_{i,t}, C_{i,t}, T_{i,t}, INV_{i,t}, \varepsilon_{i,t}) \tag{3.3}$$

where $DS_{i,t}$ = excessive housing demand, which indicates the gap between housing demand and housing supply this year; and $\varepsilon_{i,t}$ = random error term.

In macroeconomics, house prices in the previous time periods certainly have an effect on the house price in the next time period, which means there is a dynamic relationship within house prices over time. As Brooks (2008) explained, lagged values of the dependent variable may capture important dynamic structural aspects of the dependent variable. Thus, in order to investigate the dynamic effect, we will use the dynamic panel data (DPD) model from Equation 3.3, which includes the lagged dependent variable on the right-hand side of Equation 3.3 (Greene 2005, Chapter 19, pp. 558-560; Brooks 2008, Chapter 4, pp. 154-155):

$$HP_{i,t} = f(HP_{i,t-1}, Y_{i,t}, P_{i,t}, UR_{i,t}, I_{i,t}, HC_{i,t}, DS_{i,t}, C_{i,t}, T_{i,t}, INV_{i,t}, \varepsilon_{i,t}) \tag{3.4}$$

The Equation 3.4 can be simplified as follows:

$$y_{i,t} = \delta + \alpha y_{i,t-1} + \beta X_{i,t} + \varepsilon_{i,t} \tag{3.5}$$

where $X_{i,t} = [Y_{i,t}, P_{i,t}, UR_{i,t}, I_{i,t}, HC_{i,t}, DS_{i,t}, C_{i,t}, T_{i,t}, INV_{i,t}]$ are the explanatory variables.

The simple OLS regression yields plausible parameter estimates of house prices, but in fact, two major sources of bias exist in the OLS regression, unobserved heterogeneity and simultaneity, which have tended to generate less satisfactory parameter estimates. As Mileva (2007) suggested, several econometric pitfalls can arise from estimating Equation 3.5:

1. Some variables are most likely to be endogenous, which means these parameters or variables might have a correlation with the error term. Thus causality may exist in bi-direction—from house prices to housing supply and vice versa. According to Wooldridge (2010, Chapter 4, pp. 54-55) and Wooldridge (2012, Chapter 3, pp. 86-87), there are usually three possible forms of endogeneity in applied econometrics: omitted variables, measurement error and simultaneity. Omitted variables arise when some important factors should be controlled for and they are correlated with one or more of the independent variables, but usually because of data unavailability, they could not be included in a regression model. Measurement error is an issue when we would like to measure the (partial) effect of a

variable, but we can observe only an imperfect measure of it. In the case of simultaneity, at least one of the explanatory variables is determined simultaneously along with the dependent variable. The difference among the three sources of endogeneity is not always apparent, as an equation can have more than one source of endogeneity.

2. Time-invariant regional characteristics (fixed effects) of the panel data, such as geography and demographics, may be correlated with the explanatory variables as well. The fixed effects are embodied in the error term $\varepsilon_{i,t}$ of Equation 3.5, which consists of the unobserved region-specific effects (μ_i), and the observed specific error ($\upsilon_{i,t}$): $\varepsilon_{i,t} = \mu_i + \upsilon_{i,t}$. Our Equation 3.5 then can be rewritten as:

$$y_{i,t} = \delta + \alpha y_{i,t-1} + \beta X_{i,t} + \mu_i + \upsilon_{i,t} \tag{3.6}$$

3. As Wooldridge (2012, Chapter 3-4, pp. 83-119) defined, for cross-sectional regression applications, there are six general assumptions, called ‘classical linear model (CLM) assumptions’ including linearity in the parameters, no perfect collinearity, the zero conditional mean, homoscedasticity, no serial correlation, and normality of the errors:

Assumption I: Linear in Parameters

The model in the population can be written as

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

where $\beta_0, \beta_1, \ldots, \beta_k$ are the unknown parameters (constants) of interest and ε is an unobserved random error or disturbance term.

Assumption II: Random Sampling

The random sample of n observations, $\{(x_{i1}, x_{i2}, \ldots, x_{ik}, y_i): i=1, 2, \ldots, n\}$, following the population mode in Assumption I.

Assumption III: No Perfect Collinearity

In the sample (and therefore in the population), none of the independent variables is constant, and there are no exact linear relationships among the independent variables.

Assumption IV: Zero Conditional Mean

The error ε has an expected value of zero given any value of the independent variables. In other words, $E(\varepsilon \mid x_1, x_{2,} \ldots, x_k) = 0$.

Assumption V: Homoskedasticity

The error ε has the same variance given any values of the explanatory variables. In other words, $Var(\varepsilon \mid x_1, x_{2,} \ldots, x_k) = \sigma^2$.

Assumption VI: No Serial Correlation and Normality

The population error ε is independent of the explanatory variables x_1, x_2, ..., x_k and is normally distributed with zero mean and variance σ^2: $\varepsilon \sim Normal\ (0, \sigma^2)$.

Wooldridge (2012) summarises the population assumption of the CLM in a succinct way as:

$$y|\mathbf{x} \sim Normal\ (\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k, \sigma^2)$$

where **x** is the matrix of (x_1, x_2, ..., x_k). Thus, conditional on **x**, y has a normal distribution with mean linear in x_1, x_2, ..., x_k and a constant variance.

In our model, the possibility of autocorrelation is raised by the presence of the lagged dependent variable $y_{i,t-1}$, which violates strict/strong exogeneity, CLM Assumption VI; since $y_{i,t-1}$ is correlated with the past value of idiosyncratic error term $\upsilon_{i,t-2}$ at time t:

$$E(\upsilon_{i,t-2} \mid \mu_i, x_{i,} y_{i,t-1} \forall t = 1,...T) \neq 0 \qquad (3.7)$$

Furthermore, the composite error ($\varepsilon_{i,t}$) exhibits serial correlation due to the time-invariant, panel-specific unobserved effect—one of the repressors is a lagged dependent variable ($y_{i,t-1}$)—which apparently violates the weaker condition of zero contemporaneous correlation of the repressors with the composite error term $\mu_i + \upsilon_{i,t}$.

'If the time dimension T of a sample is small, the inconsistency can be particularly severe. A larger cross-section dimension N cannot help, since the number of unobserved effects

increases one-for-one with N. It is sometimes known as Nickell bias (1981).' (Bluedorn 2009)

4. The panel dataset has a short time dimension (T=11) and a relatively large area dimension (N=30).

3.3.2 Fixed Effects and Random Effects

Because of the above limitations of the OLS pooled regression, as Greene (2012, Chapter 11, pp. 386-387) suggested, alternative model structures for panel data also include Fixed Effects (FE) and Random Effects (FE) [53]. Recall our basic OLS model, $y_{i,t} = \alpha y_{i,t-1} + \beta X_{i,t} + \mu_i + \upsilon_{i,t}$, where μ_i embodies all the observable effects and specifies an estimable conditional mean. If μ_i is unobservable but uncorrelated with the explanatory variables x_{it}, then the least squares estimator β is biased and inconsistent as a consequence of an omitted variable. The FE approach takes μ_i to be a group-specific constant term in the regression. FE explores the relationship between predictor and outcome variables within an entity. Each entity has its own individual characteristics that may or may not influence the predictor variables.

When using FE we assume that something within the individual may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between the entity's error term and predictor variables. FE removes the effect of those time-invariant characteristics from the predictor variables so we can assess the predictors' net effect. Another important assumption of the FE model is that those time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics. Each entity is different therefore the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others. FEs estimator 'removes the effect of time-invariant characteristics' (see above), hence panel data models can easily correct for time-invariant unobservable effects, correlated with the observable regressors.

If the unobserved individual heterogeneity μ_i, however formulated, can be assumed to be uncorrelated with x_{it}, the model might be modified as $y_{i,t} = \alpha y_{i,t-1} + \beta X_{i,t} + \delta + \mu_i + \upsilon_{i,t}$, that is a linear regression model with a compound disturbance estimated by lease squares, which is consistent but inefficient. The random effects (RE) approach specifies that μ_i is a group-

[53] Assumptions for FE and RE, see Wooldridge, 2010, Chapter 14, Appendix 14A, pp. 509-511.

specific random element, similar to $v_{i,t}$ except that for each group, there is but a single draw that enters the regression identically in each period. An advantage of RE is that time-invariant variables can be included. In the FEs models, there are ways to recover the time-invariant parts of the model, either through the LSDV approach or, upon model estimation, by extracting the time-invariant part of the error term and regressing it on the time-invariant variables and a constant term. RE approach also needs to specify those individual characteristics that may or may not affect the predictor variables. The problem with this is that some variables may not be available therefore leading to omitted variable bias in the model. RE allows to generalise the inferences beyond the sample used in the model.

Again, the key distinction between FE and RE is whether μ_i and x_{it} are correlated, not whether these effects are stochastic or not (Greene, 2012, Chapter 11. pp. 387; Wooldridge, 2010, Chapter 10, pp. 328). The Hausman test can be used to determine the preferred model between FE and RE (Clark and Linzer, 2012; Greene, 2012, Chapter 11. Pp. 419-420; Wooldridge, 2010, Chapter 10, pp. 329-333). If there is no correlation between the independent variables and the unit effects, then estimators of β in FE ($\hat{\beta}_{FE}$) should be similar to β in RE ($\hat{\beta}_{RE}$). Thereby, the Hausman test statistic H measures the difference between $\hat{\beta}_{FE}$ and $\hat{\beta}_{RE}$:

$$H = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right)' \left[Var\left(\hat{\beta}_{FE}\right) - Var\left(\hat{\beta}_{RE}\right)\right]^{-1} \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right) \tag{3.8}$$

Under the null hypothesis H_0 of ‘difference in coefficients not systematic’, H is distributed as Chi-square with degree of freedom equal to the number of repressors in the model. Rejecting the null suggests the FE approach is preferred. In our case, after determining between FE or RE by the Hausman test, we can use the chosen approach to compare with the results of other models, as a robustness check.

3.3.3 2SLS or Instrumental Variables Estimator

The correlations between endogenous explanatory variables and the error term violate an assumption of the regression framework, which means OLS estimation will be biased. Even as the sample size approaches infinity, the estimates of the parameters on average will not equal the population estimates (Oczkowski, 2003). To remedy this bias, we would usually implement 2SLS (Two-Stage Least Squares), also called the instrumental variables (IV) estimator, to identify instruments for the endogenous variables. The 2SLS can overcome the drawbacks of the fixed-effects OLS panel estimator. Specifically, the major limitations of FE approach are failing to estimate effects of variables which vary across individuals but not over time, breaking all cross-section variation in the dependent and independent variables by controlling for omitted variables, failing to predict effects in levels outside of the sample, inefficiency if unobserved effects μ_i is uncorrelated with x_{it}, and exacerbating biases from other types of specification problems, especially measurement error (Greene, 2005, Chapter 13; Wooldridge, 2010, Chapter 10; Bollen and Brand, 2010).

The instruments of 2SLS must satisfy two conditions: (1) instruments must be uncorrelated with the error term; (2) instruments must be correlated with the replaced endogenous variables. As the 2SLS name suggests, there are two steps to get the parameter estimates by running two OLS regressions. The first step is to regress the endogenous variable on all the predetermined (exogenous) variables in the system to get predictions for the endogenous variables, and then obtain the fitted values, as the instrumental variables that are uncorrelated with the residual. The second step is to regress the initial equation by using the fitted values as instruments to replace the original endogenous variables.

A natural assumption which can locate valid instruments is sequential exogeneity (Greene 2005, Chapter 5, pp. 74-76):

$$E(\upsilon_{i,t} \mid \mu_i, x_{i,t}, x_{i,t-1},...x_{i,1}, y_{i,t}, y_{i,t-1},...y_{i,1}) = 0 \tag{3.9}$$

The only requirement of the sequential exogeneity assumption is that the idiosyncratic error ($\upsilon_{i,t}$) term has zero mean conditional upon the unobserved effect and the current set of information (the predetermined and exogenous variables). Even under this assumption, the correlation still occurs between the unobserved effect and the lagged dependent variable. In this case the usual transformation to adopt is the first-difference (FD), which can eliminate the unobserved effect (Greene 2005, Chapter 13, pp.307-308):

$$\Delta y_{i,t} = \alpha \Delta y_{i,t-1} + \beta \Delta X_{i,t} + \Delta \upsilon_{i,t} \tag{3.10}$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$, $\Delta X_{i,t} = X_{i,t} - X_{i,t-1}$, and $\Delta \upsilon_{i,t} = \upsilon_{i,t} - \upsilon_{i,t-1}$. Of course, just like FD estimation, FE estimators can eliminate the unobserved effect as well. For large N and small

T, the choice between FE and FD hinges on the relative efficiency of the estimators and this is determined by the serial correlation in the idiosyncratic errors $\upsilon_{i,t}$, which is usually difficult to test (Wooldridge 2012, Chapter 14, pp. 490). However, Greene (2005) states this model is still complicated by correlation between the lagged dependent variable and the disturbance (the first order moving average disturbance). As Bluedorn (2009) explains, the first differencing generates a negative correlation between the differenced lagged dependent variable ($\Delta y_{i,t-1}$) and the differenced idiosyncratic error term ($\Delta\upsilon_{i,t}$), which implies we still need to use an alternative IV estimation strategy.

3.3.4 Difference GMM and System GMM Method

In response to the endogeneity problems, we could use the GMM (Generalized Method of Moments) estimator, which originates with Hansen (1982). The increasingly popular dynamic panel instrument estimators were proposed by Arellano-Bond (1991), and Arellano-Bover (1995)/Blundell-Bond (1998). These are the two most common estimation strategies for dynamic panel models of the form of Equation 3.4. The application of the Arellano and Bond (1991) GMM estimator uses first differences to eliminate unobserved area-specific effects (fixed effects) and taking lagged instruments to correct for simultaneity in the first-differenced equations, and so is known as 'difference GMM'. Subsequently, Arellano and Bover (1995) generated the forward orthogonal deviations transformation instead of differencing. The Arellano-Bover/Blundell-Bond estimator expands upon the Arellano-Bond estimator via adding an additional assumption that the fixed effects are uncorrelated with the first differences of the instrument variables. The latter estimator builds up a two-equation system, the original equation and the transformed equation, and is typically called 'system GMM'. The considerations of Roodman (2009) explain well the appropriateness and efficiency of GMM estimators for our model:

'*Both are general estimators designed for situations with 1) 'small T, large N' panels, meaning few time periods and many individuals; 2) a linear functional relationship; 3) a single left-hand-side variable that is dynamic, depending on its own past realizations; 4) independent variables that are not strictly exogneous, meaning correlated with past and possibly current realizations of the error; 5) fixed individual effects; and 6) heteroskedasticity and autocorrelation within individuals, but not across them.*'

The following assumptions about the data-generating process are embodied by the difference and system GMM estimators:

The following is based on (Roodman, 2009).

'1. The process may be dynamic, with current realizations of the dependent variable influenced by past ones.

2. There may be arbitrarily distributed fixed individual effects in the dynamic, so that the dependent variable consistently changes faster for some observational units than others. This argues against cross-section regressions, which must essentially assume fixed effects away, and in favor of a panel set-up, where variation over time can be used to identify parameters.

3. Some regressors may be endogenous.

4. The idiosyncratic disturbances (those apart from the fixed effects) may have individual-specific patterns of heteroskedasticity and serial correlation.

5. The idiosyncratic disturbances are uncorrelated across individuals.

In addition, some secondary worries shape the design:

6. Some regressors may be predetermined but not strictly exogenous: even if independent of current disturbances, still influenced by past ones. The lagged dependent variable is an example.

7. The number of time periods of available data, T, may be small. (The panel is 'small T, large N.')

Finally, since the estimators are designed for general use, they do not assume that good instruments are available outside the immediate data set. In effect, it is assumed that:

8. The only available instruments are "internal"—based on lags of the instrumented variables.

However, the estimators do allow inclusion of external instruments.'

More specifically, the GMM estimator in a first-differenced dynamic panel regression, proposed by Arellano and Bond (1991), employs valid instruments for the lagged endogenous variables where the following moment conditions hold:

$$E(y_{i,t-s}\Delta\upsilon_{i,t}) = 0 \forall s = 2,...,t-1 \tag{3.11}$$

Equation 3.11, also known as the 'standard moment condition', and is widely applied in empirical estimation. The resulting instrument matrix for past values of the endogenous variable can then be expressed as:

$$Z_i^{\Delta,(y)} = \begin{bmatrix} y_{i,0} & 0 & \dots & \dots & 0 & \dots & 0 \\ 0 & y_{i,0} & y_{i,1} & 0 & 0 & \dots & 0 \\ 0 & \dots & & \vdots & \vdots & \dots & 0 \\ 0 & \dots & 0 & 0 & y_{i,0} & \dots & y_{i,t-2} \end{bmatrix} \tag{3.12}$$

Analogously, the matrix of strictly exogenous/predetermined explanatory variables ($X_{i,t-1}$) can be written as:

$$Z_i^{\Delta,(x)} = \begin{bmatrix} x'_{i,0} & \dots & x'_{i,t-1} & 0 & \dots & \dots & 0 & \dots & 0 \\ 0 & \dots & 0 & x'_{i,0} & \dots & x'_{i,t-1} & 0 & \dots & 0 \\ 0 & \dots & & & \dots & 0 & \dots & & 0 \\ 0 & \dots & \dots & & \dots & 0 & x'_{i,0} & \dots & x'_{i,t-1} \end{bmatrix} \tag{3.13}$$

Thus, the full IV set for the first differenced transformed model (Z_i^{Δ}) is that:

$$Z_i^{\Delta} = (Z_i^{\Delta,(y)}, Z_i^{\Delta,(X)}) \tag{3.14}$$

One common disadvantage of first-differenced dynamic model estimators is their weak empirical performance (Alecke, Mitze, and Untiedt; 2010): as Bond *et al.* (2010) debate, first-differenced IV/GMM estimators would be poorly behaved because lagged levels of the time series only provide 'weak instruments' for subsequent first differences. In order to remedy this critique, a second generation dynamic panel data (DPD) model has been developed, which also introduces appropriate orthogonality conditions for the equation in levels (Blundell and Bond, 1998) as:

$$E(\Delta y_{i,t-1}[\mu_i + \upsilon_{i,t}]) = 0 \forall t = 3,\dots,T \tag{3.15}$$

Rather than adopting lagged levels of variables for first-differenced equations involving the first difference estimators, an orthogonality condition can be obtained for the model in levels that uses first difference instruments. Equation 3.15 is also referred to as the 'stationarity moment condition'. Blundell and Bond (1998) suggest a GMM estimator that jointly includes both the standard and stationarity moment conditions. This approach is typically called 'system GMM' incorporating 'level' and 'difference' GMM estimators. System GMM applies the data system as a single-equation problem since the same linear functional relationship exhibits in both the transformed and untransformed variables:

$$\begin{bmatrix} \Delta y \\ y \end{bmatrix} = \alpha \begin{bmatrix} \Delta y_{-1} \\ y_{-1} \end{bmatrix} + \beta \begin{bmatrix} \Delta x_{-1} \\ x_{-1} \end{bmatrix} + \begin{bmatrix} \Delta \upsilon \\ \upsilon \end{bmatrix} \tag{3.16}$$

The overall instrument matrix in the system GMM is $Z_i = (Z_i^{\Delta}, Z_i^{L})$, where Z_i^{L} is the instrument set for the equation in levels on the valid orthogonality conditions for both $y_{i.t-1}$ and $X_{i,t-1}$.

Unlike difference GMM, where the effects of time-invariant regressors get differenced out, regressors with the time-invariant effects can be estimated as well in system GMM by adding the level version of the dynamic panel model to the differenced version. Consequently, although system GMM requires more assumptions than difference GMM, it can achieve a greater efficiency as long as the assumptions hold.

3.3.5 Tests for Overidentification and Autocorrelation

3.3.5.1 The Sargan/Hansen Test for Overidentification

The standard test of overidentifying restrictions is the Sargan (1958)/Hansen (1982) test (the Sargan or J-test), which is used for joint validity of the instruments. A critical assumption, for the validity of GMM estimators, is certainly that the instruments are exogenous. More specifically, the residuals should be uncorrelated with the set of exogenous variables if the instruments are truly valid. The statistic of the Sargan/Hansen test follows an asymptotically Chi-squared (χ^2) distribution, with the degrees of freedom equal to the number of overidentifying restrictions. The null hypothesis of the Sargan/Hansen test is that 'all the instruments are valid' (Bluedorn, 2009), or 'the instruments as a group are exogenous' (Mileva, 2007); in other words, the disturbance term is uncorrelated with the instruments. Thus, the high p-value is our favorable result: the higher p-value, the better the Sargan/Hansen statistic is.

Generally, the classic Sargan test is more favourable if errors are homoskedastic; while Hansen's J-test, based on the weighting matrix, is more favourable if errors are heteroskedastic. Although the Sargan test is more reliable, as the sample size is distorted with the growth of instrument number within Hansen test; it is not appropriate if homoskedasticity fails. Broadly speaking, the Hansen test is more robust than the Sargan test.

3.3.5.2 The Arellano-Bond Test for Autocorrelation

The Sargan/Hansen test is used for testing the joint validity of the instrument set; in addition, Arellano and Bond (1991) propose a test for a scenario that some lags of the endogenous variables would be invalid as instruments, namely, there is autocorrelation in the idiosyncratic error term ($\upsilon_{i,t}$). Apparently, the full error term ($\varepsilon_{i,t} = \mu_i + \upsilon_{i,t}$) is supposedly autocorrelated because it contains fixed effects, thus the estimators are applied to eliminate this problem. The Arellano-Bond test is employed to the differences of residuals to test for autocorrelation apart from the fixed effects. The Arellano-Bond statistic also follows an asymptotically Chi-squared (χ^2) distribution with the null hypothesis of no autocorrelation.

As Roodman (2009) explained, $\Delta\varepsilon_{i,t}$ is mathematically correlated to $\Delta\varepsilon_{i,t-1}$ by sharing the term of $\varepsilon_{i,t-1}$, there is an uninformative evidence of the negative first-order serial correlation. Therefore, in order to investigate first-order serial correlation in levels, second-order correlation in differences is quoted by estimating correlation between $\varepsilon_{i,t-1}$ in $\Delta\varepsilon_{i,t}$ and $\varepsilon_{i,t-2}$ in $\Delta\varepsilon_{i,t-2}$. In other words, the test for AR(1) in first differences usually rejects the null hypothesis; while the test for AR(2) in first differences is more important, as autocorrelation will be detected in levels. Generally speaking, the serial correlation of order *m* in levels is tested by checking for correlation of order *m+1* in differences.

However, such an approach would not work for orthogonal deviations since all error terms in deviations are mathematically inter-correlated with many forward lags. As long as none of the regressors is ‘post-determined’—based on future disturbances, the Arellano-Bond autocorrelation test is actually valid for any GMM regression on panel data, including OLS and 2SLS. Moreover, another assumption is that errors are not correlated across individuals.

3.3.6 The Long-run Equilibrium of DPD Model

Our DPD model with GMM estimator may contain many differenced and lagged terms (Roodman, 2009) that make it difficult to interpret from a theoretical perspective, and the coefficients β just illustrate the short-run effects of our variables. One interesting property of a dynamic model that can be calculated is its long-run or static equilibrium solution (Brooks, 2008; Greene, 2012). In order to investigate the long run effects, we need to induce the lag structure analysis of the dynamic regression model. Recall the DPD model is shown as Equation 3.5:

$$y_{i,t} = \delta + \alpha y_{i,t-1} + \beta X_{i,t} + \varepsilon_{i,t} \tag{3.17}$$

With the lag structure, we can get:

$$y_{i,t-1} = \delta + \alpha y_{i,t-2} + \beta X_{i,t-1} + \varepsilon_{i,t} \tag{3.18}$$

Then, we substitute Equation 3.18 into Equation 3.17 and get the finite lag model as follows:

$$\begin{aligned} y_{i,t} &= \delta + \alpha(\delta + \alpha y_{i,t-2} + \beta X_{i,t-1} + \varepsilon_{i,t}) + \beta X_{i,t} + \varepsilon_{i,t} \\ &= (1+\alpha)\delta + \beta X_{i,t} + \alpha\beta X_{i,t-1} + \alpha^2 y_{i,t-2} + (1+\alpha)\varepsilon_{i,t} \end{aligned} \tag{3.19}$$

And by this analogy, with the backward recursion of time period *t* to time period *t-p*, Equation 3.19 can be expressed as:

$$\begin{aligned} y_{i,t} &= (1+\alpha+\alpha^2+\cdots+\alpha^{p-1})\delta \\ &+ \beta X_{i,t} + \alpha\beta X_{i,t-1} + \alpha^2\beta X_{i,t-2} + \cdots + \alpha^{p-1}\beta X_{i,t-(p-1)} \\ &+ \alpha^p y_{i,t-p} + (1+\alpha+\alpha^2+\cdots+\alpha^{p-1})\varepsilon_{i,t} \end{aligned} \tag{3.20}$$

From the lag structure form of our model, we can see that the effect of the lagged dependent variables on the current house price has been trailing off with the lags of house price further in the past. Namely, Equation 3.20 indicates the coefficient of *t-p* lags of house price is α^p.

The parameters of α and β in Equation 3.17 solely demonstrate the short run effects of the explanatory variables on China's house price. While, in the long run, the dynamic model can calculate the static equilibrium solution. The long run equilibrium is defined as when the variables have attained some steady state values and are no longer changing (Brooks 2008, Chapter 4, pp. 156). Consequently, it can be written $y_{i,t} = y_{i,t-1} = \cdots = y_{i,1}$, so Equation 3.17 is transformed into:

$$\begin{aligned} & y_{i,t} = \delta + \alpha y_{i,t} + \beta X_{i,t} + \varepsilon_{i,t} \Rightarrow (1-\alpha)y_{i,t} = \delta + \beta X_{i,t} + \varepsilon_{i,t} \\ & \Rightarrow y_{i,t} = \frac{\delta}{(1-\alpha)} + \frac{\beta}{(1-\alpha)} X_{i,t} + \frac{\varepsilon_{i,t}}{(1-\alpha)} \end{aligned} \tag{3.21}$$

In the long run equilibrium, it can be seen from Equation 3.21 that the coefficients of explanatory variables X are $\frac{\beta}{(1-\alpha)}$ rather than β in the short run.

3.4 Data Source and Description

China's welfare allocation housing system was finally terminated by 1998, and then a new market-oriented housing system was established. Thus a valid dataset of the housing market can be obtained from 1999. The data used in my thesis include 30 provinces/cities (excluding Tibet, Hong Kong, Macao, and Taiwan) in China Mainland from 1999 to 2009, that are 11 East China provinces (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan), 8 Middle China provinces (Jilin, Heilongjiang, Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan), and 11 West China provinces (Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang).

The dependent variable is the real house price (*HP*). The explanatory variables include demand-side factors, such as disposable income of urban households (*Y*), the proportion of urban population (*P*), the unemployment rate in urban area (*UR*), statutory reserve ratio (*I*), housing consumption of urban households (*HC*), and floor space sold this year (*D*); and supply-side factors, such as construction cost of building completed (*C*), taxation on the use of urban land (*T*), completed investment by enterprises for real estate development this year (*INV*), floor space of building completed this year (*S*). CPI is another force of Chinese house price growth (Zeng, 2008); thus, CPI for urban areas is used to eliminate the effect of the inflation rate in my estimation, which can get the real level of variables (*HP, Y, HC, C, T* and *INV*) by taking the nominal level of variables dividing by local CPI for urban areas.

Real house price: The dependent variable, it is the real average selling price of commercialized buildings by area, where the commercialized buildings include residential buildings, office buildings, houses for business use and others.

The lag of real house price: In order to investigate the dynamic effect of house price in the previous time period on the current house prices, the lag of house prices is adopted as one of our independent variables. The involvement of a lagged dependent variable is denoted as the major idiosyncrasy of the dynamic panel data (DPD) model.

Disposable income: A majority of the literature indicates that the disposable income is one of the significant variables impacting on both foreign housing markets (Cameron, Muellbauer & Murphy, 2006; Jud & Winkler, 2002) and China's housing market (Cui, 2009; Li & Zhang, 2010; Chen, Guo & Wu, 2011; and Deng, Ma & Chiang, 2009). Therefore, the real per capita disposable income of urban households is an indispensable estimator.

Urban population proportion: From the view of demographic factors, Cui (2009), Deng, Ma & Chiang (2009), Fu (2007), Wu and Zeng (2010) use the absolute number of the urban population as an explanatory variable. But we will employ a new device of the population factor developed by Chen, Guo and Wu (2011)—the urban population proportion (urban population-to-total population), denoted as 'the urbanization level'. However, in order to check the robustness of our estimation, we could use the different variable—the urban population.

Unemployment rate in urban areas: Liu & Shen (2005) and Deng, Ma & Chiang (2009) both involve the unemployment rate as their independent variable to explain Chinese house price; However, they come to different conclusions: Liu & Shen (2005) find the effect of unemployment rate has no significant effects on house prices in China but Deng, Ma & Chiang (2009)'s evidence shows a significant effect. We will estimate the equation with unemployment rate in urban areas to find how actually it influences China's house price.

Statutory reserve ratio: In existing models, the most researchers (Fu, 2007; Deng, Ma & Chiang, 2009; and Dong, Guan & Ming, 2010) use the 'nominal six-month to one-year benchmark lending rate' denoting 'the interest rate' as an explanatory variable; while Duan (2008) adopted 'three-year loan interest rate'. However, the statutory reserve ratio for large financial institution, enacted by the central bank, is the most important monetary instrument to adjust and regulate the macroeconomy in China. In addition, the adjustment of the statutory reserve ratio is much more frequent in response to the market dynamic changes. The Table 3.2 displays that how frequent of these two variables have been adjusted, also the adjustment of statutory reserve ratio has shifted more smoothly than benchmark lending rate with approximate 0.5% interval. In order to improve the veracity of the monetary variable, we capture the statutory reserve ratio for the large financial institution firstly; then, since there might be several adjustments of the statutory reserve ratio in the same year, we use the highest ratio of each year. The statutory reserve ratio is just a minimum percent of total customer deposits and notes, and it does not need to eliminate the inflation as there is no difference between 'nominal' term and 'real' term. Again, we could use the most common factor of the benchmark lending rate to do a robustness check.

Table 3.2: The Adjustment of Statutory Reserve Ratio for Large Financial Institution and Nominal Six-month to One-year Benchmark Lending Rate

Date of Commencement	Statutory Reserve Ratio	Adjustment %	Benchmark lending rate	Adjustment %	Date of Commencement	Statutory Reserve Ratio	Adjustment %	Benchmark lending rate	Adjustment %
21/03/1998	8.00%	-5.00%			**22/08/2007**			7.02%	0.18%
01/07/1998			6.93%	-0.99%	**15/09/2007**			7.29%	0.27%
07/12/1998			6.39%	-0.54%	**25/09/2007**	12.50%	0.50%		
10/06/1999			5.85%	-0.54%	**25/10/2007**	13.00%	0.50%		
21/11/1999	6.00%	-2.00%			**26/11/2007**	13.50%	0.50%		
21/02/2002			5.31%	-0.54%	**21/12/2007**			7.47%	0.18%
21/09/2003	7.00%	1.00%			**25/12/2007**	14.50%	1.00%		
25/04/2004	7.50%	0.50%			**25/01/2008**	15.00%	0.50%		
29/10/2004			5.58%	0.27%	**25/03/2008**	15.50%	0.50%		
28/04/2006			5.85%	0.27%	**25/04/2008**	16.00%	0.50%		
05/07/2006	8.00%	0.50%			**20/05/2008**	16.50%	0.50%		
15/08/2006	8.50%	0.50%			**25/06/2008**	17.50%	1.00%		
19/08/2006			6.12%	0.27%	**16/09/2008**			7.20%	-0.27%
15/11/2006	9.50%	0.50%			**25/09/2008**	17.50%	0.00%		
15/01/2007	9.50%	0.50%			**09/10/2008**			6.93%	-0.27%
25/02/2007	10.00%	0.50%			**15/10/2008**	17.00%	-0.50%		
18/03/2007			6.39%	0.27%	**30/10/2008**			6.66%	-0.27%
16/04/2007	10.50%	0.50%			**27/11/2008**			5.58%	-1.08%
15/05/2007	11.00%	0.50%			**05/12/2008**	16.00%	-1.00%		
19/05/2007			6.57%	0.18%	**23/12/2008**			5.31%	-0.27%
05/06/2007	11.50%	0.50%			**25/12/2008**	15.50%	-0.50%		
21/07/2007			6.84%	0.27%	**18/01/2010**	16.00%	0.50%		
15/08/2007	12.00%	0.50%			**20/10/2010**			5.56%	0.25%

Data source: The People's Bank of China http://www.pbc.gov.cn/publish/zhengcehuobisi/610/index.html

Excessive housing demand: The previous studies of Chinese house prices treat the demand side and supply side separately, either using housing units sold as the demand side (Fu, 2007; Deng, Ma & Chiang, 2009; and Dong, Guan & Ming, 2010) or building completed as the supply side (Gao & Leng, 2010). Here, we introduce a new variable, denoted as 'excessive housing demand', to overlap the effects of both housing demand and housing supply. The excessive housing demand is generated by the log of housing demand (housing units sold this year) deducting the log of housing supply (building completed this year). Thus it is the log of the ratio of these two variables. In the robustness check, we could replace the excessive housing demand by two original demand-supply variables, housing units sold this year and buildings completed this year.

Construction cost and housing consumption: From the suppliers in the Chinese housing market, the effects of construction costs greatly differ for the various regions (Leung *et al.*, 2010). From the purchaser of housing, Zhou (2010) and Zeng (2008) illustrate a significant relationship between property prices and aggregate consumption. While the housing consumption more likely impacts on the house price rather than the aggregate consumption. Thus, we introduce a consuming expenditure factor, 'housing consumption', as one of the explanatory variables.

Investment completed on real estate development: Another new explanatory variable, 'investment actually completed by enterprises for real estate development this year' as a supply-side variable, is included in our model.

Urban land use tax: After the implementation of the new land transfer policy in July 2002, the land transfer fee and urban land tax have become other major determinants of Chinese house prices. Ding (2008), Yuan (2009) and Deng, Ma & Chiang (2009) elaborate the rapid increase of land prices has contributed to house price growth. Since the 'land price' means the land using right transfer fee paid by real estate developers to governments; the land transfer revenue has become one of the most important sources of total revenue for local authorities, known as the 'cash box' of local governments. The new variable—urban land use tax—is adopted as one of our explanatory variables. As mentioned before, there are many categories of taxes on urban land, therefore the alternative tax form of 'urban land value added tax' might be used to detect the efficiency of our explanatory variable in the robustness check.

Table 3.3 introduces the data source and generation of my variables. In my estimation, apart from urban population proportion (*P*), unemployment rate (*UR*) and statutory reserve ratio (*I*), all the other variables are in logarithms (log of *HP, Y, HC, D, C, T, INV* and *S*, denoting as '*LHP, LY, LHC, LD, LC, LT, LINV and LS'* respectively).

Table 3.4 describes the summary statistics of dependent variables and explanatory variables, which include their number of observations, mean standard deviation, minimal value and maximum value. From the table, we can see that the fluctuations for all the variables are drastic, which can be reflected by the big gap between their minimal values and maximal values. The disparity is still apparent even with the logarithmic values. The reasons of varying changes within variables could be raised by the differences of both the time and area dimensions. More specifically, on one side, the fundamental factors have largely ameliorated with the rapid economic growth over time; on the other side, due to the relatively large differences in development level across China, various kinds of macroeconomic indicators differ greatly between 30 provinces/cities.

Table 3.3: The Glossary of Variables

Symbol of Variables		**Name of variables**	**Variable Description**
Dependent Variables	*HP*	Real House Price (yuan/m^2)	the average selling price of commercialized buildings by area/local CPI for urban areas, where the commercialized buildings include residential buildings, office buildings, houses for business use and others.
Demand Factors	*Y*	Real Disposable Income Per Capita (yuan)	per capita annual disposable income of urban households by area/local CPI for urban areas
	P	Urban Population Proportion (%)	urban population by area/total population*100%
	UR	Unemployment Rate (%)	unemployment rate in urban area
	I	Statutory Reserve Ratio (%)	a minimum portion (expressed as a percent) of total cumtomer deposits and notes, that each commercial bank must pay as reserves to the central bank.
	HC	Real Housing Consumption (yuan)	housing consumption per capita by area/local CPI for urban areas
	D	Housing Demand (10,000 m^2)	floor space sold this year by area
Supply Factors	*C*	Real Construction Cost (yuan/m^2)	construction cost of buildings completed by area/local CPI for urban areas
	T	Urban Land Use Tax (10,000 yuan)	taxation level on the use of urban land by area
	INV	Real Investment (100 million yuan)	investment actually completed by enterprises for real estate development by area/local CPI for urban areas
	S	Housing Supply (10,000 m^2)	floor space of building completed this year by area

Notes:
1) All the statistic data, except for statutory reserve ratio, come from the 'China Statistical Yearbook' on the official webpage of 'National Bureau of Statistics of China' (NBSC) http://www.stats.gov.cn/
2) Local CPI for urban areas in each provinces/cities is also from the 'China Statistical Yearbook' on the official webpage of NBSC.
3) The statistic data of unemployment rates in urban area of Shanghai in 2001 and 2005 come from the 'Shanghai Statistical Yearbook' rather than the 'China Statistical Yearbook'.

Table 3.4: Statistics Summary

Variable		Observations	Mean	Standard Deviation	Min	Max
Initial format	house price (*HP*)	330	2550.656	1749.468	827.3662	14014.8
	disposable income (*Y*)	330	9847.686	4368.643	4325.309	28955.89
	housing consumption (*HC*)	330	258.0656	138.0645	56.27649	995.1392
	housing demand (*D*)	330	1543.823	1494.559	30.74	10248.2
	construction cost (*C*)	330	1290.471	508.1163	616.9128	3366.733
	urban land use tax (*T*)	330	86168.6	164475.6	673.7864	1209514
	investment completed (*INV*)	330	518.8621	607.9096	6.26	3352.23
	housing supply (*S*)	330	1527.575	1319.057	28.6489	8442.8
	urban population proportion (*P*)	**300**	45.2209	15.41895	23.2	89.09
	unemployment rate (*UR*)	330	3.658364	0.7471114	0.6	6.5
	statutory reserve ratio (*I*)	330	9.363636	4.140894	6.0	17.5
Logarithm format	log(HP)—*LHP*	330	7.699049	0.4953977	6.718247	9.54787
	log(Y)—*LY*	330	9.109843	0.4042798	8.372239	10.27353
	log(HC)—*LHC*	330	5.425281	0.5051711	4.030277	6.902883
	log(D)—*LD*	330	6.846706	1.10964	3.425565	9.234858
	log(C)—*LC*	330	7.096819	0.3529258	6.424727	8.121698
	log(T)—*LT*	330	10.41218	1.37157	6.512913	14.00573
	log(INV)—*LINV*	330	5.556684	1.286543	1.83418	8.117381
	log(S)—*LS*	330	6.933172	0.9894436	3.355115	9.041069
	log(DS)—*LDS*	330	-0.0864659	0.2956824	-1.147045	0.8223372

Notes:
1) The summary of statistics is provided based on a time period from 1999 to 2009 for 30 provinces/cities. Thus, except for urban population proportion (*p*), number of observation is 330 (=30*11).
2) Since the statistic data of urban population started from 2000 in the 'China Statistical Yearbook', there are 30 missing values of urban population for each provinces/cities in 1999.
3) LDS, denoting excessive housing demand, is equal to (LD-LS), the log of housing demand this year minus the log of housing supply this year.

Table 3.5 demonstrates straightforward contemporaneous correlations between house prices and other variables respectively: the positive correlations suggest disposable income, urban population proportion, statutory reserve ratio, housing consumption, construction cost, urban land use tax, completed investment and excessive housing demand have a positive effect on house prices; while the negative correlation between house prices and unemployment rate suggests that the house prices will rise with the decline of the unemployment rate. But the table indicates that the house price has a positive high correlation with other explanatory variables (all correlation coefficients are more than 50%), except for the unemployment rate and excessive housing demand (the absolute values of correlation coefficient are less than 20% and 35% respectively), which means the other explanatory variables excluding unemployment rate and excessive housing demand have strong correlation with house prices. But of course correlation is not causation and to explore further we need to employ regression analysis.

Table 3.5: Correlation between house price and other explanatory variables

	lhp	***ly***	***p***	***ur***	***i***	***lhc***	***lc***	***lt***	***linv***	***lds***
lhp	1.0000	-	-	-	-	-	-	-	-	-
ly	0.8975	1.0000	-	-	-	-	-	-	-	-
p	0.7850	0.6383	1.0000	-	-	-	-	-	-	-
ur	-0.1888	-0.0775	-0.1304	1.0000	-	-	-	-	-	-
i	0.5343	0.7186	0.1825	0.0423	1.0000	-	-	-	-	-
lhc	0.6860	0.7118	0.5955	-0.1367	0.3346	1.0000	-	-	-	-
lc	0.8836	0.8315	0.7174	-0.1442	0.5332	0.6151	1.0000	-	-	-
lt	0.5051	0.6424	0.2541	0.0139	0.6468	0.3658	0.4420	1.0000	-	-
linv	0.7084	0.8062	0.5258	-0.0038	0.5092	0.5747	0.6062	0.8117	1.0000	-
lds	0.3345	0.5096	-0.0066	0.1848	0.5766	0.1859	0.3902	0.4817	0.4388	1.0000

Note:
lhp, ly, p, ur, i, lhc, lc, lt, linv and *lds* represent log of house price, log of disposable income, urban population proportion, unemployment rate, statutory reserve ratio, log of housing consumption, log of construction cost, log of urban land use tax, log of investment completed and log of excessive housing demand respectively.

From Table 3.5, we can also see that some correlations between explanatory variables are relatively high, for instance, the lagged house price has correlation more than 50% with other explanatory variables except for unemployment rate. Thus there seems to be high collinearity between explanatory variables, which might cause problems of multicollinearity. The term multicollinearity refers to high (but not perfect) correlation between two or more independent variables, and it arises for estimating β_j when R_j^2 is 'close' to one. Here R_j^2 is the *R-squared* from regressing x_j on all other independent variables including an intercept. Since multicollinearity violates none of the CLM assumptions, there is no absolute number that we can cite to conclude that multicollinearity is a problem. The Variance Inflation Factor (VIF) can be used to detect the muiltcollinearity. The VIF for slope coefficient j is simply $VIF_j = 1/(1 - R_j^2)$, precisely the term in $Var(\hat{\beta}_j)$ that is determined by correlation between x_j and the other explanatory variables. We desire lower levels of VIF with all other things equal. (Wooldridge 2012, Chapter 3, pp. 95-98)

Although the problem of multicollinearity cannot be clearly defined, perhaps most commonly, a cut-off value of VIF is recommended as 10 (Wooldridge, 2012; Hair *et al.*, 1995; Kennedy, 1992; Neter, Wasserman and Kutner, 1989; Marquardt, 1970). Only if VIF is above 10, the multicollinearity is concluded as a 'problem'. In our dataset, we use the VIF to test the multicollinearity, and get the following results (Table 3.6):

Table 3.6: The Values of VIF

Explanatory Variable	***VIF***	***1/VIF***
ly	15.78	0.063374
L.lhp	8.79	0.113764
linv	7.53	0.132853
lc	5.15	0.194289
lt	4.77	0.209785
i	4.40	0.227465
p	4.27	0.234114
lhc	2.43	0.410930
lds	2.16	0.463701
ur	1.22	0.821443
Mean VIF	5.65	

As we can see, only the income VIF is larger than 10 (15.78), and the average VIF is 5.65, much less than 10. Therefore in our case, the multicollinearity will not to be a substantial 'problem'.

3.5 Empirical Results

3.5.1 System GMM Estimations

Based on the reasons explained in the methodology, we will use the dynamic panel data (DPD) model with both one-step and two-step system GMM methods. In our model, the lagged house price, housing vacancy, investment on real estate, urban land use tax, housing consumption and construction cost are treated as endogenous variables. The other variables—

per capita disposable income of urban householder, urban population proportion, unemployment rate in urban areas, and statutory reserve ratio—are treated as exogenous variables.

Next, the degree of freedom of the system-GMM DPD model will decline with the increase of instruments; therefore, in order to avoid weakening the estimation by too many instruments, we could 'collapse' the instruments, which means that the instrument matrix of endogenous variables can be collapsed from

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ y_{i1} & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & y_{i2} & y_{i1} & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & y_{i3} & y_{i2} & y_{i1} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix} \text{ to } \begin{bmatrix} 0 & 0 & 0 & \cdots \\ y_{i1} & 0 & 0 & \cdots \\ y_{i2} & y_{i1} & 0 & \cdots \\ y_{i3} & y_{i2} & y_{i1} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix} \tag{3.22}$$

Then, we run the regression and get the estimation results of in Table 3.7. In the general sense, the results are coincident in both one-step system GMM regression and two-step system GMM regression. The coefficients of the explanatory variables—the first lag of house prices, disposable income, statutory reserve ratios, excessive housing demand, real estate investment and urban land use tax—are mostly significant at the 1% or 5% significance level; while, the other explanatory variables—urban population proportion, unemployment rate of urban areas, housing consumption and construction cost—have insignificant coefficients.

Table 3.7: Estimation Results of System GMM Regressions

The Determinants of Chinese House Price				
Dependent Variable	real house price			
No. of Observation	300			
Explanatory Variable	**One-step System GMM**		**Two-step System GMM**	
	Coefficient	p-value	Coefficient	p-value
log of the lagged house price *(L.lhp)*	0.690 (5.35)	0.000***	0.719 (3.82)	0.001***
log of disposable income *(ly)*	0.370 (2.12)	0.044**	0.438 (2.03)	0.052*
urban population proportion *(p)*	0.002 (1.21)	0.236	0.003 (0.97)	0.342
unemployment rate in urban areas *(ur)*	-0.008 (-0.63)	0.533	0.0004 (0.03)	0.977
statutory reserve ratio *(i)*	-0.022 (-4.22)	0.000***	-0.024 (-5.56)	0.000***
excessive housing demand *(lds)*	0.155 (2.53)	0.017**	0.184 (2.94)	0.006***
log of investment completed *(linv)*	-0.092 (-2.22)	0.035**	-0.111 (-2.29)	0.030**

log of urban land use taxation *(lt)*	0.089 (2.52)	0.017**	0.088 (2.61)	0.014**
log of housing consumption *(lhc)*	-0.014 (-0.32)	0.753	-0.016 (-0.36)	0.718
log of construction cost *(lc)*	0.200 (1.59)	0.122	0.142 (1.26)	0.216
cons	-2.552 (-2.71)	0.011**	-2.867 (-2.43)	0.022**
AR(2) test (H_0=no autocorrelation)	0.084*		0.099*	
Hansen test (H_0=all instruments are valid)	0.352		0.352	
Difference in Hansen Test (GMM for levels) (H_0=exogenous instruments)	0.506		0.506	

Notes:
1). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
2). p-values are reported for the AR(2) test, Hansen test and Difference in Hansen test.
3). The standard instruments for exogenous variables are (ly, p, i, ur); the GMM-style instruments for endogenous variables are the lag 3 to lag 5 of (L.lhp, lds, lt, linv, lhc, lc).
4) *lhp, ly, p, ur, i, lhc, lc, lt, linv* and *lds* represent log of house price, log of disposable income, urban population proportion, unemployment rate, statutory reserve ratio, log of housing consumption, log of construction cost, log of urban land use tax, log of investment completed and log of excessive housing demand respectively.

The empirical results demonstrate that the lagged house prices in the previous period significantly affect the current house prices in a positive direction. More specifically, the coefficients of lagged house prices are 0.690 and 0.719 in one-step and two-step models respectively. The rationale behind the homogenous movement between house prices and lagged house prices is that, the increasing positive push on fundamentals can result in the rising of prices and expectations, and then the rising expectations lead to further over-valuation of house prices. Similarly with house price falls, the expectations of further decrease can exaggerate the price falls when prices eventually drop down.

According to the literature (Cameron, Muellbauer & Murphy, 2006; Jud & Winkler, 2002), income is one of the most important fundamental factors in the housing market. It can be seen that, the coefficient of disposable income of urban households is positively significant, which is consistent with other studies on the Chinese housing market (Cui, 2009; Li & Zhang, 2010; Chen, Guo & Wu, 2011; and Deng, Ma & Chiang, 2009). More specifically, in the short run, a 1% change of disposable income will induce a 0.370% and 0.438% change of house prices with the same direction in one-step and two-step system GMM estimations respectively. Recall the long-run effects of independent variable X in DPD model is $\beta/(1-\alpha)$ rather than β, disposable income will drive up 1.194 (=0.370/(1-0.690)) per cent and 1.559 (=0.438/(1-0.719)) per cent of the house price in the long term. This does suggest that as China becomes more prosperous, house prices will continue their rapid growth.

We obtain the same conclusion as Deng, Ma & Chiang (2009) and Wu & Zeng (2010) about the demographic factors, although they use the absolute number of urban population as an explanatory variable. In our estimation, the coefficients of the urban population proportion are not significant in both estimations, even at the 10% significance level, which indicates the fluctuation of the urban population proportion has not a significant effect on the house price change. By contrast, Chen, Guo and Wu (2011) adopted the same variable (urbanization level) as ours (the percentage of urban population) but found a significant influence on house prices.

Table 3.7 demonstrates the p-values of the t-test for unemployment rate in urban areas are 0.532 and 0.986 respectively, which thus fail to reject the null hypothesis. In other words, the unemployment rate in urban areas is an insignificant explanatory variable. This conclusion is consistent with Liu & Shen (2005), but against Deng, Ma & Chiang (2009), which indicates that the fluctuations of house prices are not well explained by unemployment rates.

The argument about the effect of monetary factors on Chinese house prices is inconclusive. The empirical analysis of Fu (2007), Deng, Ma & Chiang (2009), and Dong, Guan & Ming (2010) indicate that there is no significant relationship between Chinese property prices and the fluctuation of 'nominal six-month to one-year benchmark lending rate'. However, Zeng (2008) explored a negative shock of money supply and a positive shock of the interest rate on house prices; also, Duan (2008) found a significant role for the three-year loan interest rate. With the more precise estimator generated by the highest statutory reserve ratio[54] each year, our regressions overthrow the finding of the indistinctive impact of interest rates on house prices, as both coefficients of the statutory reserve ratio are strongly significant at the 1% significance level. Our results also correspond to the theoretical assumption: the decline of interest rates will drive up the house price and vice versa. More specifically, if statutory reserve ratio rise 1%, it will deteriorate house prices in the short run by 0.022% in the one-step model and 0.024% in the two-step model individually, and in the long run by 0.071% (=0.022/(1-0.690)) in one-step model and 0.085% (=0.024/(1-0.719)) in the two-step model respectively.

Some of the literature (Fu, 2007; Deng, Ma & Chiang, 2009; and Dong, Guan & Ming, 2010)

[54] Alternatively, instead of 'the highest statutory reserve ratio' in every year, we adopt 'the weighted average statutory reserve ratio' to estimate our equation. The regression illustrates that the effects of the interest rate in both two estimations are still quite significant on the house price. However, it will change other results of excessive housing demand and housing consumption. More specifically, the excessive housing demand will not be a significant variable any more, while the effect of housing consumption will be significant.

suggests that the impact of housing units sold has a significant effect on Chinese house prices; while others (Gao & Leng, 2010) find that there is no significant effect of building supply on house prices. The results in Table 3.7 also show that Chinese house prices can be explained significantly by our new variable—the excessive housing demand this year—obtained through using the log of housing demand minus the log of housing supply . In the short run effects, the 1% positive change in excessive housing demand indicates that house prices increase by 0.155% in the one-step regression and 0.184% in the two-step regression respectively; while in the long run, the house price will ascend by 0.500% (=0.155/(1-0.690)) and 0.655% (=0.184/(1-0.719)) individually.

Our findings suggest both real construction costs and real housing consumption per capita are not significant explanatory variables of house prices; the p-value of the t-tests illustrates both estimators fail to reject the null hypothesis at the 10% significance level. That largely depends on the fact that construction costs and housing consumption just account for a small portion of Chinese house prices to an extent, particularly in relatively developed areas, like Beijing, Shanghai and Guangdong.

With another new explanatory variable, 'investment actually completed by enterprises for real estate development this year', the results of our estimation show that the coefficient of real investment is significant at the 5% significance level. Specifically, house prices will decline by 0.092% and 0.111% individually with a 1% increase of real investment in the short term, which is consistent with the findings of Zeng (2008), Cui (2009) and Yuan (2009). Also, in the long term, real house prices will fall by 0.297% (=0.092/(1-0.690)) and 0.395% (=0.111/(1-0.719)) respectively.

Ding (2008), Yuan (2009) and Deng, Ma & Chiang (2009) discuss that the rapid increase of land prices has contributed to house price growth. In line with their evidence, our new variable, urban land use tax, shows a significant impact on house prices at the 5% significant level as well. In both regressions, an increase of 1% in the urban land use tax will push up the house prices by 0.089% and 0.088% in the short run, but by 0.287% (=0.089/(1-0.690)) and 0.313% (=0.088/(1-0.719)) respectively in the long term, which is also coincident with the theoretical conclusion of a positive relationship between house prices and urban land use tax.

Table 3.7 also shows the results of the Arellano-Bond autocorrelation test and the Hansen overidentification test. The null hypothesis of the Arellano-Bond test is no autocorrelation. Thus, the test results indicate that the autocorrelation test will fail to reject the null hypothesis at the 5% significance level, which means there is no autocorrelation at the 5% significance level in both GMM regressions. Furthermore, we can see that the two-step system GMM estimation eliminates the autocorrelation more efficiently than the one-step system GMM estimation, since the p-value of Arellano-Bond test increases from 0.084 to 0.099.

For the Hansen test, the null hypothesis of the overidentification test is ‘all instruments are valid’. We can conclude that, both tests for all instruments and test for levels, produce the same results for both estimations and fail to reject the null hypothesis at 10% significance level. The result shows our instruments are jointly valid, which also certifies the efficiency of our estimations. Overall, two-step system GMM estimation shows more efficiency than one-step system GMM regressions. Although both autocorrelation test and overidentification test reveal the efficiency of our GMM estimations, the robustness checks are still desired. After all, correlation coefficients among explanatory variables are pretty high.

3.5.2 Robustness Checks

To test the robustness of GMM results, we adopt two approaches: one is to compare with different estimation, such as FE or RE; the other is to replace some of the explanatory variables, such as the proportion of urban population, the statutory reserve ratio, the excessive housing demand, and the urban land use tax, with alternative factors, urban population, nominal six-month to one-year benchmark lending rate, housing demand (housing units sold this year), housing supply (building completed this year), and the urban land value added tax.

Table 3.8 exhibits the regression results of the FE and RE approaches respectively. Due to the exclusiveness of these two estimations, the Hausman test proposes that, the FE model is preferred with the rejection of the null hypothesis. Thus, the FE findings could be used as a comparison with GMM results. Most results with FE are consistent with the GMM regressions: the impacts of previous house prices, disposable income, the statutory serve ratio, and urban land use tax are all significant at the 5% level with quite similar coefficients; and the effects of urban population percentage, unemployment rate, and housing consumption are still not significant. However, they of course also indicate some discrepancies in the findings: compared with GMM estimation, our improved variable of excessive housing demand and investment completed do not play a significant role any more in FE, but the construction cost does. Hence, GMM estimations improved the explanatory power of excessive housing demand and investment, which FE fails to detect.

Table 3.8: Estimation Results of FE and RE Models

The Determinants of Chinese House Price				
Dependent Variable	real house price			
No. of Observation	300			
Explanatory Variable	**FE approach**		**RE approach**	
	Coefficient	p-value	Coefficient	p-value
log of the lagged house price *(L.lhp)*	0.644 (13.10)	0.000***	0.719 (3.82)	0.000***
log of disposable income *(ly)*	0.474 (5.39)	0.000***	0.438 (2.03)	0.000***
urban population proportion *(p)*	-0.004 (-1.13)	0.261	0.003 (0.97)	0.479
unemployment rate in urban areas *(ur)*	-0.020 (-1.52)	0.131	0.0004 (0.03)	0.887
statutory reserve ratio *(i)*	-0.015 (-4.75)	0.000***	-0.024 (-5.56)	0.000***
excessive housing demand *(lds)*	0.030 (0.97)	0.335	0.184 (2.94)	0.017**
log of investment completed *(linv)*	-0.013 (-0.52)	0.602	-0.111 (-2.29)	0.081*
log of urban land use taxation *(lt)*	0.029 (2.12)	0.035**	0.088 (2.61)	0.119
log of housing consumption *(lhc)*	0.001 (0.03)	0.976	-0.016 (-0.36)	0.944
log of construction cost *(lc)*	0.165 (3.63)	0.000***	0.142 (1.26)	0.001***
cons	-2.517 (-4.70)	0.000***	-2.867 (-2.43)	0.000***
Hausman Test	**Prob.>Chi-square = 0.0000 (reject the null, FE is preferred)**			

Notes:
1). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
2). H_o for Hausman test is 'difference in coefficients not systematic'; rejecting the null means the FE approach is preferred.

Table 3.9 demonstrates the results of the robustness check by using different explanatory variables (urban population instead of urban population percentage, lending rate instead of statutory reserve ratio, housing demand and housing supply instead of excessive housing demand, urban land value added tax instead of urban land use tax). The influence of population and monetary factors coincide with the original variables. This implies that regardless of any variable we used, the population does not significantly affect Chinese house prices, but the monetary adjustment does. While, the new variable of urban land value added tax is not significant, comparing with the significance of urban land use tax, that indicates the effectiveness of land variable adopted in GMM estimations.

Housing demand has a significant impact at the 5% level and housing supply at the 10% level. The original excessive housing demand factor shows a significant effect as well, in capturing the effects of both housing demand and housing supply. However, the alternative variables have changed the impact of other variables to some extent. More specifically, the original elements of income and investment fail to significantly affect house prices any more, that illustrates the new variables deteriorate the effectiveness of other original variables.

Table 3.9: Estimation Results of System GMM Regressions with Alternative Explanatory Variables

The Determinants of Chinese House Price				
Dependent Variable	real house price			
No. of Observation	300			
Explanatory Variable	**One-step System GMM**		**Two-step System GMM**	
	Coefficient	p-value	Coefficient	p-value
log of the lagged house price *(L.lhp)*	0.900 (9.98)	0.000***	0.974 (7.28)	0.000***
log of disposable income *(ly)*	0.044 (0.24)	0.812	-0.074 (-0.36)	0.718
log of urban population *(lup)*	-0.023 (-0.53)	0.602	-0.028 (-0.55)	0.590
unemployment rate in urban areas *(ur)*	-0.006 (-0.51)	0.617	0.006 (0.31)	0.762
benchmark lending rate *(ni)*	-0.030 (-3.28)	0.003***	-0.028 (-2.89)	0.007***
housing demand *(ld)*	0.224 (2.77)	0.010**	0.273 (3.11)	0.004***
housing supply *(ls)*	-0.193 (-1.97)	0.059*	-0.235 (-1.92)	0.065*
log of investment completed *(linv)*	0.006 (0.06)	0.951	0.012 (0.11)	0.914
log of land value added tax *(llvat)*	-0.015 (-1.24)	0.227	-0.019 (-1.59)	0.123
log of housing consumption *(lhc)*	0.040 (0.77)	0.446	0.084 (1.43)	0.165
log of construction cost *(lc)*	0.120 (1.08)	0.288	0.114 (1.75)	0.091*
cons	-0.352 (-0.31)	0.756	-0.083 (-0.06)	0.950
AR(2) test (H_0=no autocorrelation)	0.365		0.571	
Hansen test (H_0=all instruments are valid)	0.365		0.365	
Difference in Hansen Test (GMM for levels) (H_0=exogenous instruments)	0.500		0.500	

Notes:
1). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
2). p-values are reported for the AR(2) test, Hansen test and Difference in Hansen test.
3). The standard instruments for exogenous variables are (ly, lup, ni, ur); the GMM-style instruments for endogenous variables are the lag 3 to lag 5 of (L.lhp, ld, ls, llvat, linv, lhc, lc).
4) *lhp, ly, p, ur, i, lhc, lc, lt, linv* and *lds* represent log of house price, log of disposable income, urban population proportion, unemployment rate, statutory reserve ratio, log of housing consumption, log of construction cost, log of urban land use tax, log of investment completed and log of excessive housing demand respectively.

In summary, the efficiency and consistency of our GMM regressions have been substantiated by the robustness checks, to a great extent. The developed variables embodied are appropriate and the estimations are effective to investigate their effects on Chinese house prices. But due to the unavailability of data and the limitations of the GMM method, the future research could further improve our findings by using more data and more advanced methodology.

3.6 Conclusion

This chapter introduces dynamic panel data models with system GMM estimation, to investigate the determinants that impact on real house price variation in China by using a sample of 30 provinces/cities during the period of 1999 to 2009.

We include some conventional factors to explain house price, such as disposable income, population factors, unemployment rate, interest rate, consumption, housing demand-supply, construction cost, land factors and investment factors. But compared with the conventional explanatory factors in the literature, we make further improvements on collecting these explanatory variables.

For example, the urban population proportion is used instead of the absolute number of the urban population; for the interest rate, we use the statutory reserve ratio rather than the nominal six-month to one-year benchmark lending rate; also, aggregate consumption is replaced by real housing consumption in our equation. Excessive housing demand represents the demand-supply factor, denoted by log of housing demand minus log of housing supply in the same year; then, urban land use tax, as a new land factor variable, it is the first time it has been used in a Chinese house price model; Moreover, the investment actually completed by enterprises for real estate development measures the investment factor more precisely.

The autocorrelation test (Arellano-Bond test) and overidentification test (Hansen test) indicate our estimations are efficient, since there is no autocorrelation and all instruments are jointly valid. More importantly, both robustness checks with FE and different independent variables emphasise the efficiency and consistency of our GMM estimations. Under this circumstance, the dynamic model with the lagged house price illustrates that the current house price is significantly affected by the house price in previous time periods – possibly reflecting adjustment lags. Also, our empirical evidence suggests that most of the new improved explanatory variables have significant explanatory power for Chinese house price fluctuations, such as per capita disposable income of urban households, the statutory reserve ratio, excessive housing demand this year, urban land use tax, and investment actually completed by enterprises for real estate development this year. Moreover, their effects on house prices are more conspicuous in the long run than in the short run, since the long run coefficient $\frac{\beta}{(1-\alpha)}$ is greater than the short run coefficient β where α is positivel and less than 1. However, the coefficients of other variables, like urban population proportion, the unemployment rate in urban areas, construction cost and housing consumption of urban households, are not significantly related to Chinese house prices.

Based on the above empirical evidences, we can see that, in China's macroeconomy, Chinese house prices are significantly influenced by monetary policy and land policy, but not affected by the urbanization process. That reflects China's house price is to a great extent influenced by government's policies, which is identical with the non-fully market-oriented status quo. As Peng, Tam and Yiu (2008), Gao and Leng (2010), Dong, Guan and Ming (2010) indicated, the central and local authorities have played an important role in China's housing market. Besides, the appreciable effect of excessive housing demand and real estate investment corroborates our preceding theoretical inference that the lack of efficient investment channels and the speculative asset demand of individuals and institutions have greatly contributed to the vigorous prosperity of China's real estate market. Therefore, it is feasible and effective for the central and local authorities to administrate and regulate the Chinese house price via the policy instruments. More specifically, as Gao and Leng (2010) suggested, the government should combine the limitations of housing supply and the adjustments in monetary policy to control the excessive growth of real estate prices; meanwhile, the government needs to provide more affordable houses and low-rent housing for middle-low income families.

Chapter 4—Testing the Convergence and Ripple Effects of Regional House Prices in China

4.1 Introduction

House prices in China's metropolitan areas have recently exhibited rapid growth, which has also attracted the attention of both researchers and policy-makers and encouraged investigations into the behaviour of regional house prices[55]. This chapter is going to analyse house price diffusion in China. In a recent literature, UK regional house price convergence has been mentioned the most frequently. Therefore, the literature review will focus on the UK, accompanied with studies of other countries. However, studies on Chinese regional house prices are extremely limited. According to the existing literature, there is some evidence of convergence between regional house prices in the UK. The Chinese housing market more than likely exhibits some distinct characteristics from other fully market-oriented housing markets in the developed countries.

This chapter will use a wide range of quarterly House Price Indexes for 35 cities—30 capital cities (*Sheng Hui Cheng Shi*) and 5 municipalities with independent planning status (*Ji Hua Dan Lie Shi*)[56]— in the period from 1998Q1 to 2010Q4. Prior to employing stochastic approaches, the original house price Link Index will be transformed into a usable index, i.e. a continuous index. Then, some recent and innovational methodologies which have not been used on the Chinese market as yet, such as univariate/panel unit root tests, σ-/β-convergence analysis, panel regression models, Engle-Granger/Johansen cointegration tests and Granger causality tests, will be used.

Generally speaking, the findings of some approaches show that there is no evidence of convergence between regional house prices in China, such as unit root tests and σ-/β-convergence. While to some extent, further results of panel regression models, cointegration tests and causality tests suggest that there exists ripple effects from several core cities, such as

[55] The different parts of this chapter have been published in *Applied Economics Letters*, *European Journal of Business Research,* and the *'International Academic Conference on Social Sciences (IACSS 2013)'* proceeding book.

[56] Five municipalities with independent planning status are Dalian, Qingdao, Ningbo, Xiamen and Shenzhen approved by The State Council of China on 18th July 1984, 15th October 1986, 24th February 1987, 18th April 1988 and 3rd October 1988 respectively. The municipalities with independent planning status are big cities with more than 15 billion yuan gross social output value and more than 1 million population. With the strong industrial and commercial foundation and advanced science and technology, they play a significant role in the economic development of China. They are independent accounts in the state planning like other capital cities; under the direct instructions from the State, they have the decision-making power and economic management power at the provincial level.

Beijing, Shanghai, Guangzhou and Shenzhen, to other generic cities. Even so, the Chinese regional house prices might show convergence in the future, when economic growth stabilises, as the current time period is an extraordinary stage of economic growth in China.

Our chapter proceeds as follow. This first section is the 'Introduction'; the next section is a 'Literature Review' on both the Chinese housing market and other economies' housing markets; the section of 'Methodology' introduces the techniques used in this chapter, specifically unit root tests, σ-/β-convergence, panel regression models, cointegration tests and causality tests; the fourth section is 'Data Description and Data Transformation', primarily describing the data and data transformations; the following part is the 'Empirical Results', which explains our findings through the above approaches. The 'Conclusion' is of course the last section.

4.2 Literature Review

4.2.1 Literature on the Convergence and Ripple Effects of Regional House Prices Worldwide

With the worldwide real estate boom in the 1990s, an extensive literature has comprehensively analysed the properties and behaviour of regional house prices by principally focusing on testing the convergence or ripple effects of regional house prices in a certain economy, such as the U.S. (Gallet, 2004; Clark and Coggin, 2009; Holmes, Otero, and Panagiotidis, 2011; Kim and Rous, 2012), UK (Holmans, 1990; Gussani and Hadjimatheou, 1991; MacDonald and Taylor, 1993; Alexander and Barrow, 1994; Drake, 1995; Ashworth and Parker, 1997; Mean, 1999; Cook, 2003; Cook and Thomas, 2003; Holmes, 2007; Holmes and Grimes, 2008; Cook, 2012) and Taiwan (Chien, 2010; Lee and Chien, 2011; Chen, Chien and Lee, 2011).

As a result of the immobility of housing assets, there are reasons to expect the variations in regional house prices to be persistent or even be permanent; therefore, much of the literature tries to explain the structure of regional house prices. Around the world, the studies of convergence and ripple effects in regional house prices appeared the earliest and were most popular in the UK. Therefore the broad literature, concentrated on the UK, has provided us with examples to allow us to study the Chinese case. More importantly, the mega city of London is a large metropolitan centre, with the housing market significantly different from the rest of the country. This might be a similar parallel to China, as Beijing is also a huge urban centre, and the housing market in the remainder of the country bears significantly distinctive natures.

As early as in the 1990s, a range of studies supported the hypothesis of a causal link between house prices in the South East and other regions in the UK, through cross-correlation matrices and Granger causality tests (Holmans, 1990; Gussani and Hadjimatheou, 1991; MacDonald and Taylor, 1993; Alexander and Barrow, 1994). Not all the findings are consistent with the convergence hypothesis in the UK. For example, using the Augmented Dickey-Fuller unit root test as a means of detecting convergence, Holmans (1990) fails to find evidence of stationary over a long time period of data from the 1930s. Analogously, Meen (1999) and Peterson *et al.* (2002) examine the constancy, or stationarity in regional/national house price ratios. MacDonald & Taylor (1993) and Alexander & Barrow (1994) examine whether regional house prices are tied together in a long-run relationship over time, implying structural stability in house prices for different regions. So far, the evidence illustrates that there seems to exist a long-run relationship, but only within either the North or the South of Great Britain.

Alexander and Barrow (1994) use a methodology of cross correlation matrices and Granger causality tests to estimate causality between regional house prices. This approach is similar to the literature on the ‘ripple effect’, whereby shocks to house prices firstly observed in the South East ‘ripple’ across to other regions. Meanwhile, most studies, by using a range of ‘forcing’ economic variables—income and opportunity cost variables—into the equations, indicate a clear mode of causality spreading from the South East via the Midlands to the North in the UK, (MacDonald and Taylor, 1993; Alexander and Barrow, 1994).

With respect to testing for convergence of UK regional house prices, Drake (1995) adopts the time varying parameter (TVP) technique (Kalman, 1960) to examine the basic equation as follows:

$$[\log HPUK - \log HPWM](t) = a(t) + b(t)[\log HPUK - \log HPSE] \tag{4.1}$$

where *HPUK* is the index of UK house prices; *HPSE* is the index of house prices in the South East; *HPWM* is the house price index of the specified region (the West Midlands in this case). This type of specification aims to test two hypotheses simultaneously. Firstly, if the West

Midlands and UK series are converged, b is expected to be 0. Therefore, if the two series were in the process of converging, the time varying parameter estimate of b is tending towards 0 over time. Secondly, if the West Midlands and South East series are converging, b is expected to approach unity over time. Alternatively, if the gap between house prices in the South East and other regions, such as the northern regions, was tending to widen over time, b is tending to diverge away from unity over time. Clearly, if the movements of regional house prices are genuinely dominated by a 'ripple effect' emanating from the South East, there will be clear evidence of cyclical effects with the b coefficient alternately converging towards 1 and diverging away from 1 but remaining relatively stable over the longer term reflecting the hypothesized 'norm' differential between house prices in the South East and in other regions.

In the late 1980s and early 1990s, Drake finds evidence of convergence in most regional house prices. His results imply that regional differentials vary across the UK and there is greater house price divergence from the North and Scotland to the South East region than from the Southern to Midlands regions.

Compared with the above studies, Ashworth and Parker (1997) use the maximum likelihood VAR cointegration approach to estimate the determinants of house prices in each of the eleven regions of the UK (Anglia, East Midlands, Northern Ireland, North, North West, Scotland, South East, South West, Wales, West Midlands, Yorkshire). They derive an econometric estimation model from Drake (1995)'s specification written as:

$$\ln HP_t = \beta_1 \ln Y_t + \beta_2 R_t + \beta_3 \ln PSHS_t \tag{4.2}$$

where HP is house price, Y is household income, R is an opportunity cost variable, and $PSHS$ is personal sector housing starts; whereby, the Y and R are 'demand side' variables and $PSHS$ is a 'supply side' variable.

Based on the investigation of the regional structure of UK house prices since the end of mortgage rationing, Ashworth and Parker's findings show that the strong structural similarities in house price determinant are present across the regions in the UK, with cointegration for each region except for Scotland and Northern Ireland, and with some slight and geographically variable negative impacts on house prices from the opportunity costs. This implies the differences in regional house prices between England and Wales are likely to come from the differences in regional incomes, opportunity cost, and housing starts.

Although of course R is unlikely to differ between regions if it is dominated by interest rates.

As Meen (1999) points out, one implication of the ripple effect is the existence of a long-run constancy or stationarity in the ratio of house prices in different regions to the aggregate UK house prices. Meen (1999) and Petersen *et al.* (2002) were unable to present evidence to support the above implication through standard econometric techniques; despite their assumption of the existence of such convergence. However, Cook (2003) proposes an approach with an underlying asymmetry in the adjustment process to examine regional house price ratios. His work primarily was based on the unit root tests as well. The results suggest that the South East regions exhibit more rapid convergence following a drop in house price, while other regions experience faster convergence following upswings in house prices.

In the same year, Cook and Thomas (2003) produced alternative approaches—Friedman's non-parametric test of ranking and business cycle dating procedures—to verify the results of the ripple effects. Wherein the Friedman test statistic (*Fr*) is calculated as below:

$$Fr = \left[\frac{12}{T(k)(k+1)} \sum_{j=1}^{k} S_j^2 \right] - 3T(k+1) \tag{4.3}$$

where T refers to the number of observations, k refers to the number of regions and S_j^2 refers to the sum of squared rankings[57] for region j. The sum of ranks (S_j) for the regions of the UK illustrates the variation in house price volatility. To examine whether the increased volatility is significant, the *Fr* statistic can be compared to a χ^2_{k-1} critical value. They also employ the business cycle dating techniques of Birchenhall *et al.* (2001). With the integration of the two approaches, they supply strong evidence that the changes of house prices occur earlier and more extensively in the South East of England than other regions in the UK.

In recent years, some new evidence from panel datasets indicates the convergence of regional house prices in the UK (Holmes, 2007; Holmes and Grimes, 2008). Holmes (2007) employs a three-stage testing approach for regional house price convergence by using quarterly data from 1973 to 2005. The first stage includes the standard univariate ADF unit root tests on house price differentials. The second stage uses the panel data unit root tests which offer enhanced test power over the univariate counterparts. The last stage adopts an alternative

[57] In each period, the regions are ranked by the absolute value of the logarithm of house prices, with the ranking 1 awarded to the region with the smallest absolute value and 11 awarded to the region with the greatest absolute value.

procedure of SURADF (Seemingly Unrelated Regression Augmented Dickey-Fuller).

The regional house price differential for region *i* is defined as d_{it};

$$d_{it} = X_{it} - M_{it} \tag{4.4}$$

where *X* denotes the natural logarithm of the house price index of region *i* and *M* denotes the natural logarithm of the UK house price index, *i* = 1,2,…*N* regions and *t* = 1,2,…*T* time periods. Suppose d_{it} is generated by a first order autoregressive process, $d_{it} = \kappa_i + \rho_i d_{it-1} + \omega_{it}$ which can be transformed into the familiar panel ADF regression:

$$\Delta d_{it} = \kappa_i + \tau_i d_{it-1} + \sum_{j=1}^{k_i} \nu_{ij} \Delta d_{it-j} + \varepsilon_{it} \tag{4.5}$$

where $\tau_i = \rho_i - 1$. The null hypothesis (H_0) of ADF is τ_i=0 (ρ_i=1). The acceptance of H_0 means that d_{it} is non-stationary; whereas the rejection of H_0 indicates d_{it} is stationary, which refers to the existence of a long-run convergence of regional house price indices. Alternatively, he utilizes another two panel unit root tests by Levin *at al* (2002) and Im *et al.* (2003) to increase the power of his stationary results.

In the last stage, Holmes (2007) uses a recently advocated SURADF test by Breuer *et al.* (2002) based on SUR analysis with no cross panel restrictions under either the null or alternative hypotheses. More specifically, a series of equations for the SURADF method can be expressed as follows:

$$\begin{aligned}
&\Delta d_{1t} = \kappa_1 + \tau_1 d_{1t-1} + \sum_{j=1} \nu_{1j} \Delta d_{1t-j} + \eta_{1t} \\
&\Delta d_{2t} = \kappa_2 + \tau_2 d_{2t-1} + \sum_{j=1} \nu_{2j} \Delta d_{2t-j} + \eta_{2t} \\
&\dots\dots\dots\dots \\
&\Delta d_{Nt} = \kappa_N + \tau_N d_{Nt-1} + \sum_{j=1} \nu_{Nj} \Delta d_{Nt-j} + \eta_{Nt}
\end{aligned} \tag{4.6}$$

where η_i denotes the SUR residual for region *i*. The critical values for τ_i in the SURADF test are generated through Monte Carlo Simulations. This test can amend the joint null hypothesis of non-stationary ($\tau_1 = \tau_2 = \ldots = \tau_N = 0$) by relaxing the restriction $\tau_1 = \tau_2 = \ldots = \tau_N$, and identify which panel members are stationary or non-stationary based on individual rather than joint hypotheses.

In Holmes's (2007) work, the application of univariate ADF tests provides evidence strongly against long-run convergence because the majority of regions' house price differentials are non-stationary at the 5% significance level, except for London and the Northern regions. His SURADF findings imply that most of the 13 regions exhibit *regional* house price convergence, which are linked by long-run homogeneous cointegrating relationships. However, there is an east-west split in terms of whether regional house prices have a tendency towards a long-run equilibrium relationship with UK prices as a whole. There is evidence of segmentation because three regions—the South West, Wales and West Midlands do not show long-run convergence with the UK house price series.

Holmes and Grimes (2008) proposed a similar procedure to investigate the long-run convergence of UK regional house prices. Their two-stage application includes: Stage One involving a new unit root test of the first principal component[58] based on regional-national house price differentials by using mix-adjusted quarterly data from 1973 to 2006. All data used in this study are mix-adjusted to allow for variations in housing quality when computing the regional or national house price series.[59] Stage Two involves the SURADF test as well. They find the first principal component is stationary, which shows that a single common stochastic trend drives all UK regional house prices. Furthermore, their results imply that those regions, that are more distant from London, exhibit the highest degree of persistence in line with deviations in house price differentials.

A more recent study on UK regional house prices is proposed by Cook (2012), which employs the notions of β-convergence (Drennan and Lobo, 1999) and σ-convergence (Friedman, 1992; Quah, 1993), that are applied to test the convergence of income. Friedman (1992) argues that the convergence of income distribution across the given country can be

[58] 'Principal components represent transformations of the original dataset. If the original dataset comprises N series, the first principal component will be a linear combination of these N series combined in such a way that it summarises the maximum possible variation in the original series. The second principal component then summarises the maximum variation in the unexplained portion of the original series after extracting the influence of the first principal component, and so on up to the Nth principal component.' (Holmes and Grimes, 2008, pp.1532)

[59] 'The purpose of mix adjustment is to isolate pure price changes. One can show how changes in the mixture of properties sold each quarter could give a misleading picture of what is actually happening to house prices. Moreover, the set of properties sold from quarter to quarter will vary by location and design etc. and some adjustment is necessary to make sure these factors do not give a false impression of the actual changes to house prices. A mix-adjusted or 'standardised' index is not affected by such changes because the relative weight given to each characteristic of a property in the 'mix' (or 'basket', to use an analogy with consumer prices) is fixed from one-quarter to the next.' (Holmes and Grimes, 2008, pp.1542)

tested more appropriately by simply tracking the intertemporal change of the coefficient of variation. Sala-i-Martin (1996) defines this notion of convergence as 'σ-convergence'.

Simply, based on conditional probabilities of high and low growth rates, the β-convergence is to test the reaction of the growth rate of regional house prices on its level value of house prices in a previous time period. β is the coefficient of the bivariate regression and the convergence test is if β is significantly less than 0. While σ-convergence is achieved by calculating the coefficient of variation across all regions for each year with its movements through each time period. Cook's work demonstrates there is β-convergence not only over the full sample of observations available, but over cyclical sub-samples also; however, the findings of σ-convergence fail to detect convergence, probably as a result of its episodic nature.

Apart from the UK cases, there are also other studies on the convergence of regional house prices in other economies, such as Taiwan and the USA. For the regional house prices in Taiwan, Chien (2010) applies the endogenous two-break LM (Lagrangian Multiplier) method unit root test derived by Lee and Strazicich (2003) to overcome the bias and spurious rejections of the conventional unit root test without structural breaks. The empirical findings support that there are ripple effects for each city in Taiwan except Taipei City.

More than that, Lee and Chien (2011) find a mixture of stationary and non-stationary processes for Taiwan's regional house prices from 1996Q1 to 2009Q2 by employing the panel SURADF test as well. In addition, their results of the cointegration test show a long-run relationship among all regions except Taipei City, indicating a diffusion of regional house prices among each regional market except Taipei City. Innovatively, a new analysis of half-lives is introduced in their work to estimate the speed of adjustment back towards the long-run equilibrium, where the 'half-life' is defined as the number of periods required for a unit shock to dissipate by one half. This approach supposes the deviations of the real regional house prices $Z_{i,t}$ from the long-run value $Z_{i,0}$ follow an AR(1) process:

$$Z_{i,t} - Z_{i,0} = \alpha(Z_{i,t-1} - Z_{i,0}) + \varepsilon_{i,t} \tag{4.7}$$

where $\varepsilon_{i,t}$ is the error term. The half-life is defined as the horizon at which the percentage deviation from the long-run equilibrium is one half—that is:

$$\alpha^h = \frac{1}{2} \Rightarrow h = \frac{\ln\left(1/2\right)}{\ln(\alpha)} \tag{4.8}$$

In the USA, many scholars have done some work on testing the convergence of house prices. For example, by utilizing the application of the ADF unit root test, Gallet (2004) examines the convergence of house prices in the Los Angeles region via single-family house price data over 1992Q1 to 2001Q3 and Clark and Coggin (2009) investigate the convergence of U.S. regional house prices from 1975Q1 to 2005Q2. Gallet (2004) suggests that the convergence of house prices is specific to various county clusters, implying there are unique housing markets throughout the LA region. Clark and Coggin (2009) divide nine U.S. regional house price indexes into two groups by principal components factor analysis, where Factor 1 includes the four lowest ranked regions by mean price level for the full period and Factor 2 includes the five highest ranked. He finds the two super-regions have slightly different patterns of house price trends and cycles, which indicates mixed evidence for regional convergence in the U.S, with little evidence for a first super regional factor and some examples of relative convergence within the second factor.

Subsequently, Kim and Rous (2012) suggest that there is little evidence of overall convergence in panels of U.S. states and metropolitan areas through the log t convergence test advocated by Phillips and Sul (2007). Therefore, they investigate the general characteristics of the various convergence and divergence subgroups as well as some primary driving forces of convergence clubs. Alternatively, Holmes *et al.* (2011) discuss long-run house price convergence across the U.S through a novel econometric approach—a pair-wise approach—proposed by Pesaran (2007) and Pesaran *et al.* (2009). The basic idea of Pesaran's pair-wise approach is to examine the time series properties of all *N(N-1)/2* possible house price differentials/gaps between any two states, and then apply the ADF test to each of the possible house price differentials. They also construct confidence intervals and find evidence of convergence by utilizing a sieve bootstrap procedure. In addition, their findings show that the speed of adjustment towards long-run equilibrium is inversely related to distance; in another words, the farther the distance of two states are apart, the slower the speed of adjustment is.

To sum up, the current literature on regional house price convergence mainly focuses on the univariate/panel ADF unit root test and other derivative unit root tests as well, such as

SURADF unit root test and the two-break LM unit root test *etc* (Cook, 2003; Gallet, 2004; Holmes, 2007; Holmes and Grimes, 2008; Clark and Coggin, 2009; Chien, 2010; Lee and Chien, 2011). The alternative approaches applied to convergence analysis include Granger causality tests (Holmans, 1990; Gussani and Hadjimatheou, 1991; MacDonald and Taylor, 1993; Alexander and Barrow, 1994), the time varying parameter (TVP) estimation (Drake, 1995), Friedman's non-parametric test (Cook and Thomas, 2003), log *t* convergence (Kim and Rous, 2012), a pair-wise approach (Holmes *et al.*, 2011), β -convergence and σ -convergence (Cook, 2012). Specifically, the following table summarises the major literature on the convergence and ripple effect of regional house prices across the world. This literature mainly focuses on the convergence of regional house prices of the UK, the USA and Taiwan, initially starting from the UK and more recently for the USA and Taiwan.

Table 4.1: The Summary of Literature on the Convergence and Ripple Effect of Regional House Prices in the Worldwide

Country	Paper	Methodology	Conclusion
UK	Holmans (1990)	ADF unit root test and Granger causality test	Fail to find evidence of stationarity over a long time period, which indicates no evidence for convergence.
	MacDonald and Taylor (1993)	Engle-Granger cointegration test and Johansen cointegration test	Evidence of a segmentation of housing markets in Britain, linked through East Anglia, with Southern Britain on the one side and the Midlands, the North, Wales and Scotland on the other. The interaction amongst regional house prices clearly revealed the oft-quoted 'ripple down' effect.
	Alexander and Barrow (1994)	Granger causality test	Shocks to house prices firstly observed in the South East 'ripple' across to other regions. Meanwhile, a range of 'forcing' economic variables indicates a clear mode of causality spreading from the South East via the Midlands to the North in the UK.
	Drake (1995)	TVP estimation	Regional differentials vary across the UK and there is greater house price divergence from the North and Scotland to the South East region than from the Southern to Midlands regions.
	Ashworth and Parker (1997)	Maximum likelihood VAR cointegration	The strong structural similarities in house price determinant are present across the regions in the UK, with cointegration for each region except for Scotland and Northern Ireland, and with some slight and geographically variable negative impacts on house prices from the opportunity costs.
	Mean (1999), Petersen *et al.* (2002)	Unit root test for the regional-national house price ratios	Unable to present evidence to support the implication of the existence of a long-run constancy or stationary through standard econometric techniques.
	Cook (2003)	Unit root tests with an underlying asymmetry in the adjustment process	The South East regions exhibit rapider convergence following a drop in house price, while other regions experience faster convergence flowing upswings in house prices.
	Cook and	Friedman test	There is strong evidence that the changes of house prices

	Thomas (2003)	statistic (*Fr*)	occur earlier and more extensively in the South East of England than other regions in the UK.
	Holmes (2007)	Univariate ADF unit root test, panel unit root test, and SURADF test	The application of univariate ADF tests is strongly against long-run convergence, except for London and the Northern regions. His SURADF findings imply that most of the 13 regions exhibit regional house price convergence. However, there is an east-west split in terms of whether regional house prices have tendency towards long-run equilibrium relationship with UK prices as whole.
	Holmes and Grimes (2008)	Unit root test for the first principal component, and SURADF test	The first principal component is stationary, which shows that a single common stochastic trend drives all UK regional house prices. Furthermore, their results imply that those regions, that are more distant from London, exhibit the highest degrees of persistence in line with deviations in house price differentials.
	Cook (2012)	β-convergence and σ-convergence	There is β-convergence not only over the full sample of observations available, but over cyclical sub-samples also; however, the findings of σ-convergence fail to detect convergence, probably as a result of its episodic nature.
USA	Gallet (2004)	ADF unit root test	The convergence of house prices is specific to various county clusters, implying there are unique housing markets throughout the Los Angeles region.
	Clark and Coggin (2009)	ADF unit root test with principal components factor analysis	Two super-regions have slightly different patterns of house price trend and cycles, which indicates mixed evidence for regional convergence in the U.S, with little evidence for first super regional factor and some examples of relative convergence within the second factor.
	Kim and Rous (2012)	Log *t* convergence test	There is little evidence of overall convergence in panels of U.S. states and metropolitan areas by investigating the general characteristics of the various convergence and divergence subgroups as well as some primary driving forces of convergence clubs.
	Holmes *et al.* (2011)	ADF test via pairwise approach	The speed of adjustment towards long-run equilibrium is inversely related to distance; in another words, the farther the distance of two states is, the slower the speed of adjustment is.
Taiwan	Chien (2010)	Endogenous two-break LM method unit root test	There are ripple effects for each city in Taiwan except Taipei City.
	Lee and Chien (2011)	Panel SURADF test, cointegration test and 'half-life' analysis	There is a long-run relationship among all regions except Taipei City, indicating a diffusion of regional house prices among each regional market except Taipei City.

4.2.2 Literature on the Convergence and Ripple Effects of Regional House Prices in China

In the current world, studying the convergence and ripple effects of regional house prices has been popularised for the developed countries using comprehensive and cutting-edge technologies. However, there is an extremely limited literature on testing China's regional house price convergence or ripple effects (Liu and Zhang, 2008; Zhang and Liu, 2009).

In 2008, Liu and Zhang applied a qualitative model—the Regional Economy Three-sector Equilibrium Model proposed by Dipasquale and Wheaton (1996)—to examine house price ripple effects within cities. In their model, a regional economy consists of three parts: regional product market (including product and service)[60], regional labour market and regional housing market. These three markets in the same city are interrelated and interact with each other. Liu and Zhang (2008) assert that the housing market is decided by the product market and labour market, and at the same time the product market and labour market are affected by the housing market. Moreover, they incorporate external regions and analyse how the external factors affect the internal product market and internal labour market and affect the internal house prices, which is the 'house price ripple effect'. Eventually, they draw the relationship of house prices between big and small cities as Figure 4.1 shows where the house price of the big city is the determinant of the house price of the middle/small city regardless of whether the house price rises or drops. Therefore the house price of the big city leads to ripple effect on the small city.

Afterwards, based on quantitative econometric principles, Zhang and Liu (2009) select eight main capital cities' house price indexes (Beijing, Chengdu, Harbin, Hangzhou, Nanjing, Shanghai, Shenzhen and Xi'an) from the second quarter of 1998 to the fourth quarter of 2007, and then investigate the ripple effects of house prices between cities by using the univariate unit root test, the Engle-Granger test and the error correction model. Their findings reveal that there are ripple effects between eight cities' house price indices; simultaneously, the significant evidence shows that Shenzhen is the original region of nationwide house price rising and Beijing and Shanghai are the secondary ones.

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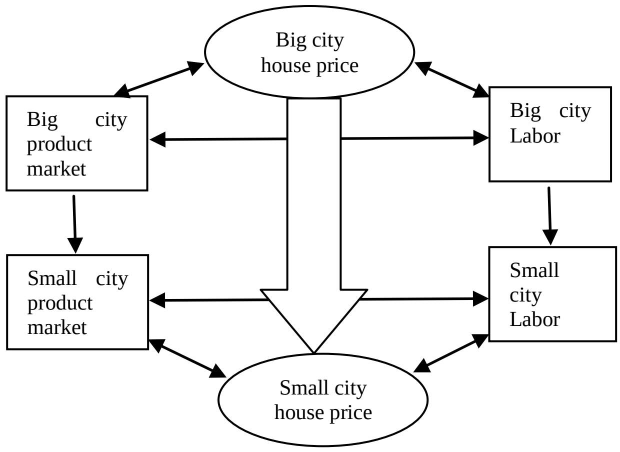
[60] The product and service is a final good and service, which is not include the exchange of raw materials, scarce resources, factors of production, or any type of intermediate goods.



(Source: Liu and Zhang 2008, Figure 4, pp.498)

Figure 4.1: Theoretical interaction model of house prices

Unfortunately, there is little literature on the convergence and ripple effects of Chinese regional house prices, apart from Zhang and Liu's work. Even though Liu and Zhang achieved some results on the regional house prices in China, the limited data set for both the geographical dimension and the time dimension make their conclusions somewhat unconvincing. China is a large country with many different geographical areas, while there are only 8 cities that they selected; and their time period across 1998 to 2007 only covers the effects of the 1997 Asian Financial Crisis excluding the more influential global financial crisis of 2008. Another major limitation of their work is that the house price index they used is a link index based on the same quarter of last year. This kind of link index is not sufficient for econometric estimations. In order to generate more persuasive findings, in our estimation the link index of house prices will be transformed into a new continual index.

4.3 Methodology

4.3.1 Unit Root Tests

4.3.1.1 Univariate Unit Root Test

Dickey and Fuller (1979) generated a classic paper about unit root test in the econometric literature, which is named the 'DF unit root test'. Firstly, consider a simple general AR(p) process of a time series model as:

$$Y_t = \alpha + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t \tag{4.9}$$

An AR(1) model can be given by:

$$Y_t = \alpha + \varphi_1 Y_{t-1} + \upsilon_t \tag{4.10}$$

where

$$\upsilon_t = \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t \tag{4.11}$$

Due to the presence of the lagged Y terms, the autocorrelation between υ_t and υ_{t-k} for k>1 will be non-zero. Therefore, considering the autocorrelations of the residual from the fitted models can aid to check whether it is appropriate to fit the AR(1) model.

In order to demonstrate the extended autoregressive process of the DF test with the order greater than 1, an AR(2) process can be expressed as:

$$Y_t = \alpha + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varepsilon_t \tag{4.12}$$

By adding $\varphi_2 Y_{t-1}$ and subtracting $\varphi_2 Y_{t-1}$ on the right side of Equation 4.12, it can be re-written as:

$$Y_t = \alpha + (\varphi_1 + \varphi_2) Y_{t-1} - \varphi_2 (Y_{t-1} - Y_{t-2}) + \varepsilon_t \tag{4.13}$$

Then subtracting Y_{t-1} from both sides, we can get:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \mu_1 \Delta Y_{t-1} + \varepsilon_t \tag{4.14}$$

where $\beta = \varphi_1 + \varphi_2 - 1$ and $\mu_1 = -\varphi_2$.

Equation 4.14 implies if the appropriate order of the AR process is 2 rather than 1, the term ΔY_{t-1} should be included in the regression model. A unit root test can be carried out in the same way as for the DF test, whereby the t-statistics of the β coefficient is used as the unit root test statistics. This test is to examine the t-statistic, then comparing it with the critical value provided by Dickey and Fuller. $\beta = 0$ means there is a unit root, indicating no stationarity.

Therefore, a unit root test on an AR(p) model can be performed by extending Equation 4.14 on the same principle:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \sum_{j=1}^{p} \mu_j \Delta Y_{t-j} + \varepsilon_t \tag{4.15}$$

The standard Dickey-Fuller model has been 'augmented' by ΔY_{t-j}. In this case, the ADF test referred to the regression model and the 't-test' of coefficient β with the null hypothesis of a unit root $\beta = 0$.

Referring to our estimation, to test the convergence of regional house prices in China the ratios of regional-national house price indexes for each city (35 cities) will be examined by the ADF test individually. Moreover, in order to support the ADF test, other univariate unit root tests are conducted, such as Dickey-Fuller GLS (DF-GLS) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. If the regional-national house price ratio is stationary, there is evidence of an equilibrium relationship between regional house prices and national house prices[61].

4.3.1.2 Panel Unit Root Test

The studies of panel unit root tests have quickly increased since Abuaf and Jorion (1990) applied a panel unit root test to real exchange rates. A substantial contribution has been done by Im *et al.* (2003), Levin *et al.* (2002), and Hadri (2000) to the asymptotic theory and finite sample properties of panel unit root tests. Their work discloses that the univariate time series unit root tests such as the ADF test are not able to take cross sectional information into account (Guloglu and Ivrendi, 2010). Therefore, due to a relatively smaller sample size, the univariate unit root tests have fewer degrees of freedom than the panel unit root tests; consequently, they have lower power on explaining the stationarity. However, the efficiency of estimation can be improved by the panel unit root tests. Levin *et al.* (2002) find that even relatively small panels offer large improvements in power when compared to univariate time series unit root tests.

The general model of a panel model with *N* cross sections and *T* periods can be expressed as:

[61] In fact, the unit root tests for house price ratios can also be achieved by the bivariate cointegration tests between the regional house price and the national house price, since both tests for different variables have the same logical explanation. We will discuss more about the comparison of these two methods later.

$$\Delta Y_{i,t} = \alpha_i + \beta_i Y_{i,t-1} + \delta_i t + \sum_{j=1}^{p_j} \mu_{ij} \Delta Y_{i,t-j} + \varepsilon_{i,t} \tag{4.16}$$

where t is a time trend and $t = 1,2,\ldots T$.

The panel unit root tests based on the ADF, Im *et al.* (2003) and Levin *et al.* (2002) start with the null hypothesis of a unit root for all panel members. The exception to this approach is the Hadri (2000) test with the null hypothesis of stationarity rather than a unit root.

The difference between these tests is their specification of the null and alternative hypotheses. Abuaf and Jorion (1990), and Levin *et al.* (2002) assume the coefficient of the lagged dependent variable to be homogenous across all sections ($\beta_i = \beta = 0, i = 1,2,\ldots,N$, where N is the number of cross sections), where the null and alternative hypotheses are: $H_0 : \beta_i = \beta = 0, (i = 1,2,\ldots,N)$ and $H_1 : \beta_i = \beta < 0$.

By contrast, Im *et al.* (2003) loosen the restriction to allow for different first-order autoregressive coefficients, where the null and alternative hypotheses are: $H_0 : \beta_i = 0$ for all i and $H_1 : \beta_i < 0$ for at least one i.

The assumption of the panel unit root tests mentioned above is that all series in the panel are independently generated and the error term ($\varepsilon_{i,t}$) in Equation 4.16 consists of two random components: one is the idiosyncratic random component and the other is a stationary common time-specific effect. This indicates that the common time-specific effect exists across cross-sections. Nevertheless, shocks can possibly affect house prices differently over time. Thus the assumption of common time-specific effects is most likely unrealistic (Guloglu and Ivrendi, 2010).

Because of the existence of the common time-specific effect ('$\delta_i t$' in Equation 4.16) across all cross-sections, Levin *et al.* (2002) and Im *et al.* (2003) propose to subtract cross-sectional averages from observations to reduce contemporaneous correlations in order to address the weakness of cross-section dependence. But this procedure is only valid under the assumption that the cross-sectional correlations are generated by a common stationary time-specific effect. Furthermore, as Luintel (2001) explained, this approach can only reduce the cross-sectional correlations rather than fully eliminate them.

Again, if the regional-national house price ratios pass the panel unit root test, there is the evidence of convergence between regional house prices and the national level. Nevertheless, in order to investigate the convergence with 'clubs', we can employ the unit root tests on the ratios of two cities. More specifically, to estimate the convergence of house prices between other cities and the base city (such as 'Beijing'), the house price ratios ($HPI_i/HPI_{Beijing}$) can be tested by the unit root techniques. In order to supplement the disadvantages of unit root tests, alternative approaches will be applied to test the convergence of regional house prices, such as σ- and β-convergence analysis. What is more, it is necessary to apply the unit root tests for the regional house price indices, because the stochastic techniques used later (the panel regression model, cointegration tests and Granger causality tests) need to identify the stationarity of data series.

4.3.2 σ-convergence and β-convergence

The use of unit root tests is referred to as a means of examining stochastic convergence, with movement towards underlying equilibria considered. The alternative common forms of convergence in the economic growth literature are referred to as σ-convergence and β-convergence. Cook (2012, pp. 205-206) describes these two notions as:

"The first of these notions, σ-convergence, refers to the narrowing of the spread of the cross-sectional distribution of a group of series over time. In the context of the analysis of regional house prices, this necessitates calculation of the coefficient of variation across regions for each time-period, prior to examining changes in this coefficient through time. If the coefficient decreases through time, the spread can be seen to narrow and hence convergence can be deemed to have occurred. The second form of convergence, β-convergence, refers to the notion of series with lower (higher) initial values experiencing faster (slower) growth than series with higher (lower) initial values. Hence, β-convergence refers to a drawing-together of differing series via the initial gaps between them closing. If lower (higher) initial values do lead to higher (lower) growth as required under β-convergence, the coefficient on the initial level term will be negative. Hence, subsequent testing for the presence of β-convergence is based upon this coefficient being significantly negative."

4.3.2.1 σ-convergence

The studies of σ-convergence have been developed by Friedman (1992) and Quah (1993) to test the convergence of some macroeconomic variables, GDP and income across countries. Cook (2012) applies σ-convergence as one of the comparable methodologies to analysis the convergence of UK house prices. As they suggest, the existence of σ-convergence is implied by the decline of the coefficient of variation.

To use the σ-convergence test for China's house price indexes, the coefficient of variation is calculated across all regions/cities for each quarter, with its movements chronicled. The coefficient of variation of regional house price indexes (CV_t) is $CV_t = \frac{S.D_t}{\overline{X_t}}$, where $S.D_t$ and $\overline{X_t}$ are the standard deviation and the average value of regional house price indexes respectively at time *t*. Therefore, if the value of CV_t is decreasing, there will be evidence of σ-convergence between regional house prices in China.

4.3.2.2 β-convergence

To compare with the unit root tests for convergence, an alternative form is considered, which is β-convergence promoted by Drennan and Lobo (1999) and Cook (2012). In the early 1990s, Sala-i-Martin (1996) discusses the income convergence in the USA and illustrates the difference between σ-convergence and β-convergence: the former indicates how the distribution of income evolves over time and the latter shows the mobility of income within the same distribution. Afterwards, Arbia, Basile and Piras (2005) develop two kinds of β-convergence—the cross-section β-convergence and the panel β-convergence—to analyse regional growth behaviour in Italy. Recently, Cook (2012) has applied the β-convergence test with UK regional house prices.

As they argue, β-convergence aims to use a regression equation in which the growth rate is regressed against the initial level. In the cross-section version, the house price growth rate for each city needs to be identified firstly in the following way:

$$GHPI = (HPI_N - HPI_1) / HPI_1 * 100 \tag{4.17}$$

where *GHPI* is the growth rate, HPI_N is the house price index in the last period, and HPI_1 is the house price in the first period. After obtaining the growth rates for all the regions, the cross-section regression is run between the growth rate and the house price index in the first time period:

$$G_i = \alpha + \beta HPI_{i,1} + \varepsilon \tag{4.18}$$

where G_i is the growth rate for region *i*, $HPI_{i,1}$ is the house price index of region *i* in the first time period, and ε is the error term.

One of the major advantages of the panel data approach to convergence is that it can be helpful for the correction of the bias generated by omitted variables and heterogeneity in the classical cross-sectional regression (Islam, 2003). Panel data, in fact, allows for technological differences across regions (or at least the unobservable and unmeasurable part of these differences) by modelling the regional specific effect (Arbia *et al.*, 2005). More formally, the panel version of the growth equation can be expressed as:

$$GHPI_{i,t} = \alpha + \beta HPI_{i,t-1} + \varepsilon \tag{4.19}$$

where $GHPI_{i,t}$ is the growth rate of HPI (House Price Index) for region *i* in the time period *t*; $HPI_{i,t-1}$ is HPI for region *i* in the previous time period *t-1*; and ε is the error term.

Hereby, for both β-convergence models, if the coefficient β is negative and significant, we can say there is β-convergence between regional house prices in China, and the house prices in cities with lower house prices grow faster than in cities with higher house prices.

To speak of panel β-convergence, recent research has drawn attention to the issue of cyclicality in the housing market. A salient extension of the analysis of convergence is then based upon the recognition of the potential importance of cyclical factors and the examination of sub-samples based upon cyclical movements (Cook, 2012). To explore the possibility of convergence in regional house prices over cyclical sub-samples, Cook and Thomas (2003) employ London as the region with which to determine cyclical peaks and troughs to identify the turning-points with the techniques of Birchenhall *et al.* (2001).[62] The

[62] Cook and Thomas (2003) identify peaks as periods with values: greater than or equal to values observed in the previous two years; strictly greater than values in the following six months; and, greater than or equal to values observed between six months and two years ahead. Conversely, troughs are defined as periods with values (i) less than or equal to values observed in the previous two years, (ii) strictly less than values in the following six months and (iii) less than or equal to values

sub-sample convergence consideration can be employed into our investigation as well, if there is such a cyclical movement of regional house prices in China.

The next step will adopt cointegration test, panel regression models and Granger Causality tests to examine the ripple effects of regional house price changes, which can further verify whether these findings coincide with the convergence analysis.

4.3.3 Cointegration Tests

4.3.3.1 Engle-Granger Cointegration Test for Bivariate Model

Engle and Granger (1987) propose a widely-accepted cointegration test called the ‘Engle-Granger Cointegration Test’ to estimate the long run equilibrium relationship between two series. The ‘Engle-Granger Test’ is based on the ADF test for the unit roots in the residuals from a single estimated cointegrating relationship. The cointegration test requires all series to be I(1) or have unit roots, which means all series are not stationary (Greene, 2007). As reviewed by Granger, Huang and Yang (2000), the Engle-Granger cointegration test is a two-stage process of which the first step is to estimate the following bivariate linear OLS regression (*x* and *y*):

$$y_t = \alpha + \beta x_t + e_t \tag{4.20}$$

where y_t and x_t are I(1) and e_t is the error term. The second step is to test the stationarity of e_t via the ADF unit root test. If e_t is consistent with I(0), one may assert that cointegration exist between y_t and x_t, which indicates there is a long run equilibrium relationship between two series; but if e_t is not stationary, then cointegration does not exist.

In reality, macroeconomic variables are usually affected by the lagged value of the dependent variable and the seasonal impact as well. Therefore, the lagged values and seasonal dummy variables can be included in our estimations when investigating the cointegration of house prices between different regions. In this case, the expanded Engle-Granger cointegration regression with seasonal dummies can be expressed as:

$$y_t = \alpha + \sum_{i=0}^{k} \beta_i x_{t-i} + \gamma_i D_i + e_t \tag{4.21}$$

---

observed between six months and two years ahead.

where D_i denotes the dummy variable. In the seasonal dummy model, i = 1,2,3 which indicates the first quarter, the second quarter and the third quarter respectively. $D_i = 1$ for the quarter i; otherwise, $D_i = 0$. The lag length of the Engle-Granger test can be chosen by using information criteria, such as AIC[63] or SIC[64].

As we mentioned before[65], the logic behind the bivariate cointegration tests is similar with the principle of the stationarity tests for house price ratios. For instance, if we need to investigate the equilibrium of house prices between city X and city Y, the equation for the cointegration test can be written as: $\ln HP_y = \alpha + \beta \ln HP_x + \varepsilon$. If they are cointegrated, the coefficient of β will be one and the equation will be expressed as: $\ln HP_y - \ln HP_x = \alpha + \varepsilon$, and then $\ln(HP_y / HP_x) = \alpha + \varepsilon$. Since $\alpha + E(\varepsilon)$ will be constant when there is cointegration, $\ln(HP_y/HP_x)$ will be constant as well, which suggest the house price ratios between city X and city Y is constant or stationary. These two tests can mutually represent each other's results.

4.3.3.2 Johansen Cointegration Test for Multivariate Model

Greene (2007) explains the 'Engle-Granger method is based on assessing whether single-equation estimations of the equilibrium errors appear to be stationary. In contrast to the Engle-Granger estimation based on a single OLS estimation, Johansen (1991, 1995) performs a VAR-based approach to test for more than one cointegrating relationship between multivariate series. All the variables are assumed to be endogenous, although it is possible to include exogenous variables.

Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \tag{4.22}$$

where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t is a vector of innovations[66]. This VAR can be rewritten as:

[63] AIC: the Akaike Information Criterion (Akaike, 1974)
[64] SIC: the Schwarz Information Criterion (Schwartz, 1978)
[65] In section '5.2.1.1 Univariate Unit Root Tests'
[66] Eviews 7 User Guide II, pp. 685-686

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \tag{4.23}$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I\,, \qquad \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{4.24}$$

Granger's representation theorem claims that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ of dimension ($k \times r$) and ($r \times k$) respectively, and $\beta' y_t$ is I(0). β gives the long-run coefficients of the cointegrating vectors, α is known as the vector of adjustment parameters which are similar to error correction terms. r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. When $r = 0$, there are no cointegrating vectors. If there are k variables in the system of equations, there can be a maximum of k-1 cointegrating vectors. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

Similarly, we can also add dummy variables into the 'Johansen Cointegration Test', such as seasonal dummies. The lag length of the Johansen test can be chosen by using information criteria as well, such as AIC or SIC.

4.3.4 Panel Regression Model for Ripple Effects

The panel regression models are also applied to the estimation of the ripple effects of regional house prices in China. In line with the development strategy of China's central government, there are three major economic zones leading the whole macroeconomic revolution across China[67]: The Beijing-Tianjin-Tangshan economic community (BTT-EC), Yangtze River Delta economic community (YRD-EC) and Pearl River Delta economic community (PRD-EC). Beijing, Shanghai and Guangzhou, are the core cities of these three economic circles respectively, and their economic development conditions affect other cities' or regions'; thus, the growth of HPI in Beijing, Shanghai and Guangzhou may be expected to 'ripple out' to

[67] Since the 1990s, the big urban economic circles have been growing up in China. Therein, three major economic zones have raised people's attention and been very much formed after 2000. They are generally called as BTT-EC, YRD-EC and PRD-EC by economists (Zuo, 2003; Chen, 2003).

other cities. In order to examine the ripple effects of house prices in these three core cities, a linear panel regression model is established by using panel HPI data:

$$HPI_{i,t} = \alpha + \delta_1 HPI_{B,t-1} + \delta_2 HPI_{S,t-1} + \delta_3 HPI_{G,t-1} + \beta HPI_{i,t-1} + \varepsilon_{i,t} \tag{4.25}$$

where t denotes the time period from 1998Q1 to 2010Q4; $i=1,2,\ldots,32$, which denotes 32 cities except for Beijing, Shanghai and Guangzhou. HPI_B, HPI_S and HPI_G are house price indexes of Beijing, Shanghai and Guangzhou respectively. We are going to test the significance of the coefficients for HPI_B, HPI_S and HPI_G: if their coefficients (δ) are significant, that indicates the house prices in the core cities have a ripple effect to the other cities' house prices.

In addition, the disparity of house prices can be induced by the diverse development levels across eastern coastal cities to western inland cities to some extent; consequently, our model will include some geographic parameters to investigate the impact of geographic factors for the house price index, such as the distance between other cities and the three core cities[68]. In this case, three new variables are applied to Equation 4.25: $DHPI_B$, $DHPI_S$ and $DHPI_G$, which are the distance between city i and core cities multiplied by HPI in the core cities. In this case, the extended panel regression can be given by:

$$\begin{aligned} &HPI_{i,t} = \alpha + \delta_1 HPI_{B,t-1} + \delta_2 HPI_{S,t-1} + \delta_3 HPI_{G,t-1} \\ &\eta_1 DHPI_{B,t-1} + \eta_2 DHPI_{S,t-1} + \eta_3 DHPI_{G,t-1} + \beta HPI_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{4.26}$$

wherein: $$\begin{aligned} DHPI_B &= L_B * HPI_B \\ DHPI_S &= L_S * HPI_S \\ DHPI_G &= L_G * HPI_G \end{aligned}$$

Where L_B, L_S and L_G are the log distance between city i and Beijing, Shanghai and Guangzhou respectively; HPI_B, HPI_S and HPI_G are house price index (HPI) in Beijing, Shanghai and Guangzhou respectively. If the coefficients (η) are significant, that indicates the ripple effects of regional house prices are also affected by the geographic factor—the distance to the core cities.

[68] Ashworth and Parker (1997) mentioned the geographically variable negative impacts on house prices. In addition, Holmes *et al* (2011) also illustrates the effects of distance on the speed of adjustment of the long-run house price convergence.

4.3.5 Granger Causality Tests

As noted by Greene (2007), causality defined by Granger (1969) and Sims (1972) is inferred when the past value of a variable X has explanatory power in a regression of a variable Y on the past values of Y and X. Such regressions do not imply causality as economists generally use the term, but it may be suggestive of such causality. In order to complement the implications of panel regression models, the Granger Causality Test is used to investigate whether each city's house price shocks 'Granger cause' other cities' house price changes or not.

As Granger (1969) defined, the 'Granger Causality Test' is a statistical hypothesis of causality to test whether one factor causes another based on prediction. Simply, if a time-series variable X 'Granger causes' variable Y, then lagged values of X should contain information forecasting Y above and beyond the information included in lagged value of Y alone. The mathematical formulation of the Granger Causality Test is based on linear regression modelling of stochastic processes (Granger 1969). The null hypothesis is 'A does not cause B'. This test requires that all the variables to be stationary, which means unit root tests need to be done prior to the causality test. If variables are not stationary, the difference format of variables needs to be introduced into the Granger causality estimations.

Additionally, as Granger, Huang and Yang (2000) suggested, this causality test uses different models to investigate the short-run relationship between variables regarding the existence of cointegration. Thus after the Engle-Granger cointegration test, if the cointegration does not exist, a bivariate linear autoregressive model of two variables X and Y is performed by the following VAR:

$$\begin{aligned} \Delta X_t &= \alpha + \sum_{i=1}^{k} \beta_i \Delta X_{t-i} + \sum_{i=1}^{k} \chi_i \Delta Y_{t-i} + \varepsilon_{1t} \\ \Delta Y_t &= \delta + \sum_{i=1}^{k} \phi_i \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta X_{t-i} + \varepsilon_{2t} \end{aligned} \tag{4.27}$$

In our samples, the bi-variable Granger Causality tests are performed using each of two cities' house price changes as variables X and Y. The F-test for joint significance of the lagged explanatory variables is conducted to determine if there is any evidence of causality from Y to X in first equation and from X to Y in second equation. Failing to reject the H_0: $\chi_1 = \chi_2 =$

$\ldots = \chi_k = 0$ suggests that Y does not Granger cause X. Likewise, failing to reject the H_0: $\gamma_1 = \gamma_2 = \ldots = \gamma_k = 0$ implies that X does not Granger cause Y.

If cointegration exists between X and Y, an error correction term (ECM) is required in testing Granger causality as shown below:

$$\begin{aligned} \Delta X_t &= \alpha + \lambda_1 (X_{t-1} - \rho Y_{t-1}) + \sum_{i=1}^{k} \beta_i \Delta X_{t-i} + \sum_{i=1}^{k} \chi_i \Delta Y_{t-i} + \varepsilon_{1t} \\ \Delta Y_t &= \delta + \lambda_2 (X_{t-1} - \rho Y_{t-1}) + \sum_{i=1}^{k} \phi_i \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta X_{t-i} + \varepsilon_{2t} \end{aligned} \tag{4.28}$$

where λ_1 and λ_2 denote speeds of adjustment. According to Engle and Granger (1987), the existence of cointegration implies a causality among the set of variables as manifested by $|\lambda_1| + |\lambda_2| > 0$. Failing to reject the H_0: $\chi_1 = \chi_2 = \ldots = \chi_k = 0$ and $\lambda_1 = 0$ indicates that Y does not Granger cause X while failing to reject the H_0: $\gamma_1 = \gamma_2 = \ldots = \gamma_k = 0$ and $\lambda_2 = 0$ implies that X does not Granger cause Y.

The lag length of the VAR can be chosen by using information criteria, such as AIC or SIC. Due to the quarterly data we used, the number of lags is fixed at 2. The Granger Causality test is run in both directions between each of two cities, so called ‘Pairwise Granger Causality Test’.

4.3.6 Conclusion of Methodology

To sum up, this chapter applies unit root tests and σ-/β-convergence methods to analyse the convergence of regional house prices in China. The alternative approaches including, panel regression models, the cointegration tests and Granger causality tests are conducted to find evidence of ripple effects between house price changes. Through comparing the results of these methods, we can verify the existence of convergence or non-convergence of house prices within regions.

Specifically, unit root tests are used prior to the cointegration test and the causality tests, because both estimations need to identify the stationarity of the variables. The cointegration test is to investigate the long-run equilibrium relationship between variables and needs variables to be I(1), based on the ADF unit root test. However, the Granger causality test is to investigate the short-run relationship between variables and needs variables to be stationary, so the difference format of data will be used for this test.

Moreover, the Engle-Granger cointegration tests are used for the bivariate model and Johansen cointegration tests are used for the multivariate model. After running the cointegration tests, if there is no cointegration, the VAR model is applied for the Granger causality test; otherwise, if there is cointegration, the ECM model is applied for the Granger causality tests (Granger *et al.*, 2000).

4.4 Data Description and Transformation

4.4.1 Data Description

All the studies mentioned above on regional house price convergence adopt the quarterly date across different regions. Therefore, this chapter will use the house price link index (HPI)[69] (the same quarter of last year=100) for 35 cities from 1998Q1 to 2010Q4, wherein 35 cities include 30 capital cities and 5 municipalities (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen) with independent planning status (see Table 4.2). Each city will be indicated by the city code (1, 2,…, 35). The link index of HPI data comes from the official database of the NBSC (http://www.stats.gov.cn/). Except for regional HPIs, another variable involved is the highway mileage between other cities and Beijing/Shanghai/Guangzhou respectively. The reason for using highway mileage as the distance factor is that, currently this form of vehicle transportation is the most dominant travel type for Chinese people. On the one hand, the cost of flight tickets is relatively high for low income groups, and the railway network is not as developed as the motorway network in China. On the other hand, the wealthier individuals purchase their own private cars and use highways instead of using public transportation. Table 4.3 shows the distance between different cities. In order to display the geographic location of cities, Figure 4.2 shows the map of China with 35 cities' locations.

Table 4.2: Classes and City Codes of 35 cities

City Code	Cities	Classes of Cities	City Code	Cities	Classes of Cities

[69] Link index is based on the same quarter of last year; for example, if the index of 1998Q1=100, 1998Q2=100, 1998Q3=100, and 1998Q4=100; then the index of 1999Q1 is based on 1998Q1, 1999Q2 is based on 1998Q2, 1999Q3 is based on 1998Q3, and 1999Q4 is based on 1998Q4.

1	Beijing	Beijing	19	Nanjing	Capital city of Jiangsu
2	Changchun	Capital city of Jilin	20	Nanning	Capital city of Guangxi
3	Changsha	Capital city of Hunan	21	Ningbo	Municipality in Zhejiang
4	Chengdu	Capital city of Sichuan	22	Qingdao	Municipality in Shandong
5	Chongqing	Chongqing	23	Shanghai	Shanghai
6	Dalian	Municipality in Liaoning	24	Shenyang	Capital city of Liaoning
7	Fuzhou	Capital city of Fujian	25	Shenzhen	Municipality in Guangdong
8	Guangzhou	Capital city of Guangdong	26	Shijiazhuang	Capital city of Hebei
9	Guiyang	Capital city of Guizhou	27	Taiyuan	Capital city of Shanxi
10	Haikou	Capital city of Hainan	28	Tianjin	Tianjin
11	Hangzhou	Capital city of Zhejiang	29	Urumchi	Capital city of Xinjiang
12	Harbin	Capital city of Heilongjiang	30	Wuhan	Capital city of Hubei
13	Hefei	Capital city of Anhui	31	Xi'an	Capital city of Shaanxi
14	Hohhot	Capital city of Inner Mongolia	32	Xiamen	Municipality in Fujian
15	Jinan	Capital city of Shandong	33	Xining	Capital city of Qinghai
16	Kunming	Capital city of Yunnan	34	Yinchuan	Capital city of Ningxia
17	Lanzhou	Capital city of Gansu	35	Zhengzhou	Capital city of Henan
18	Nanchang	Capital city of Jiangxi	-	-	-

Table 4.3: Highway Mileage between Cities (km)

Distance (km)	**Beijing**	**Shanghai**	**Guangzhou**	**Distance (km)**	**Beijing**	**Shanghai**	**Guangzhou**
Beijing	-	1490	2478	Qingdao	832	1006	2121
Tianjin	118	1380	2374	Zhengzhou	722	1095	1756
Shijiazhuang	279	1338	2199	Wuhan	1253	919	1225
Taiyuan	503	1562	2251	Changsha	1645	1223	833
Hohhot	578	2068	2840	Guangzhou	2478	1653	-
Shenyang	717	2084	3078	Shenzhen	2639	1814	161
Dalian	903	2270	3264	Nanning	2657	2195	729
Changchun	1032	2399	3393	Haikou	2777	2131	612
Harbin	1392	2759	3753	Chongqing	2136	2150	1870
Shanghai	1490	-	1653	Chengdu	2161	2411	2200
Nanjing	1141	349	1540	Guiyang	2618	2121	1359
Hangzhou	1493	213	1440	Kunming	3228	2786	1706
Ningbo	1448	301	1434	Xi'an	1224	1498	2033
Hefei	1106	511	1378	Lanzhou	1782	2189	2724
Fuzhou	2257	1107	985	Xining	2006	2413	2948
Xiamen	2216	1069	688	Yinchuan	1253	2178	2713
Nanchang	1609	837	875	Urumchi	3820	4227	4762
Jinan	457	1033	2027	-	-	-	-

Data Source: Nanning (China-ASEAN) Commodity Exchange, http://www.ncce.biz/

Figure 4.2: China Map with 35 Cities' Geographic Locations

Figure 4.3 plots the link index of house prices for each city, and Figure 4.4 plots the house price indices by groups based upon their geographic locations through putting close cities together. These are link indices and more actually reflect house price changes over a year than a house price index per quarter. Some basic characteristics of regional house prices can be described from the two figures. From the overall trend, Figure 4.3 indicates several significant peaks for the link index of HPIs: the first peak stage appeared between 2002 and 2004, which is most likely affected by the implementation of a new land policy in 2002—the 'Bidding Auction Listing Transferring State-owned Land Use Rights Provision'; then, China's house prices experienced the second boom period in 2007; but under the impact of the global financial crisis, the house prices sharply dropped in 2008 and fell to the bottom in 2009. Lately, in 2010, China's economy then started to recover from the financial crisis and the HPIs have returned to growth.

Combining the two figures, we can also see that the link HPIs in most cities range between 90 and 120 over the time period, except for Shanghai, Urumchi, Haikou and Shenzhen. The HPIs have risen to extraordinary peak values—129.1 for Shanghai in 2003Q4, 124.5 for Urumchi in 2008Q1, and 152.2 for Haikou in 2010Q2. Furthermore, Shenzhen's HPI fell to the minimum value of 85.1 during the global financial crisis in 2009Q1. These cities' extreme price indexes exactly reflect the above prosperity and depression stages in China. But, the link index (the same quarter of last year=100) cannot be used for our econometrical methods, as we need an index where all of the values are related to some base quarter when the index was 100; so in order to investigate more precise relationships between China's regional HPIs, we need to replace the link index by such an index (the first quarter=100), which use quarter 1998Q1 as the base period.

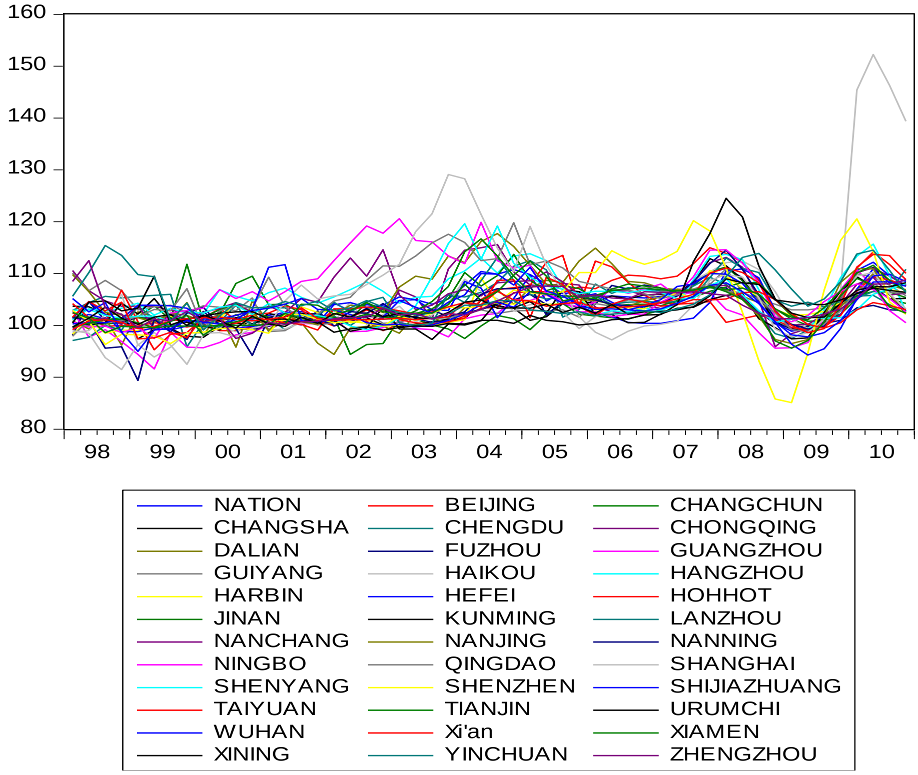
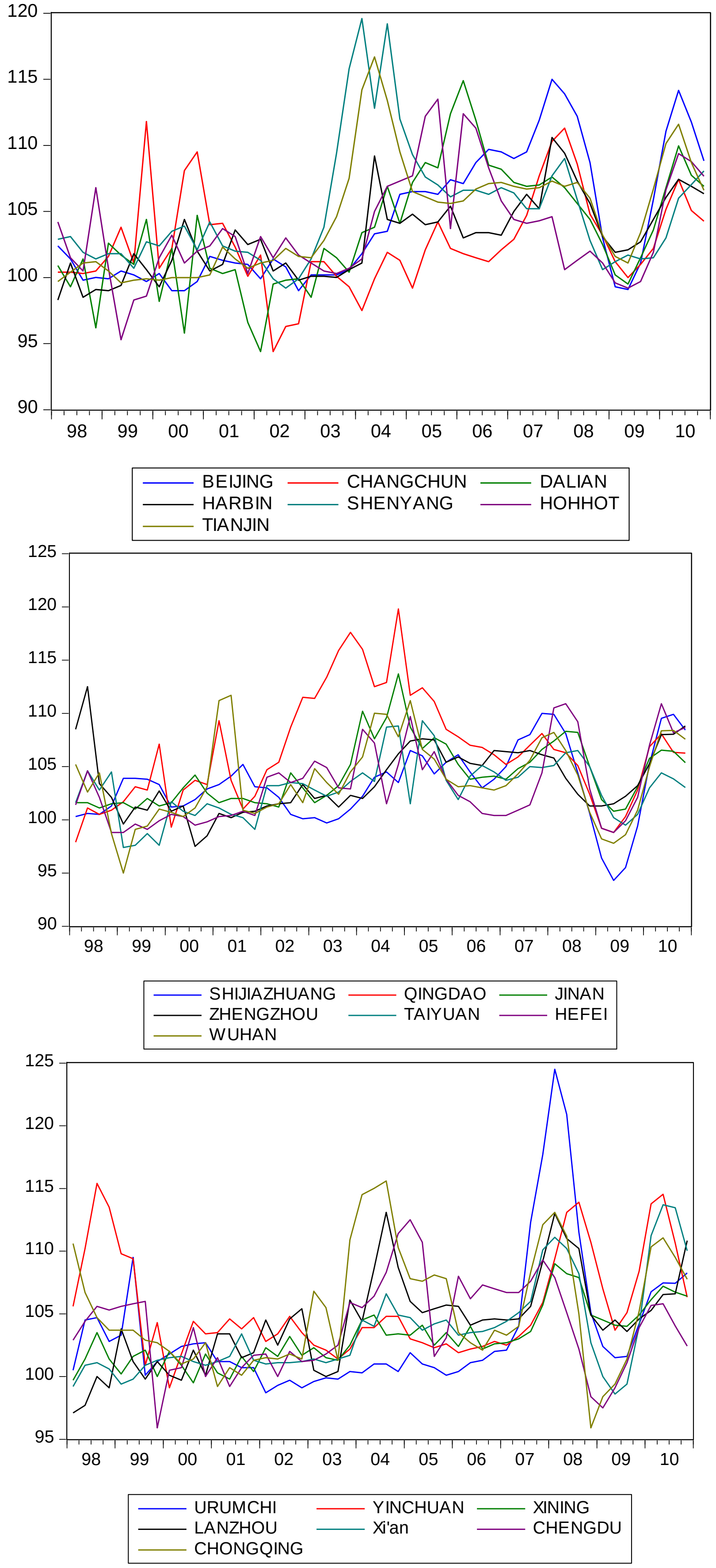
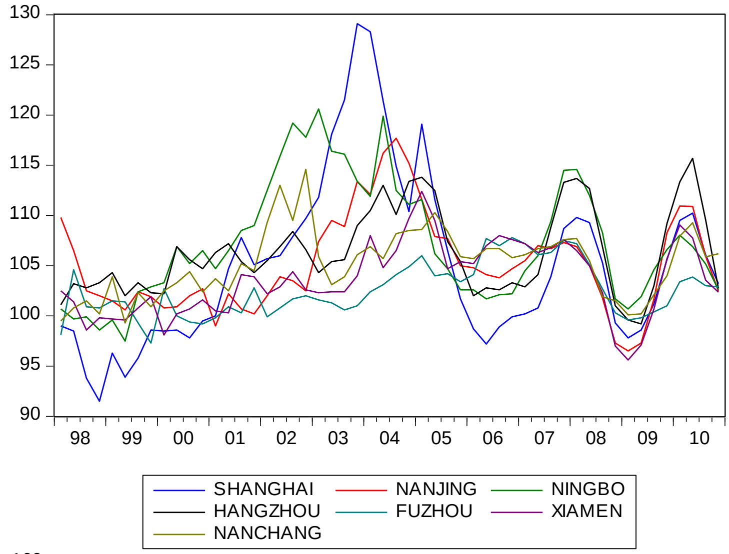
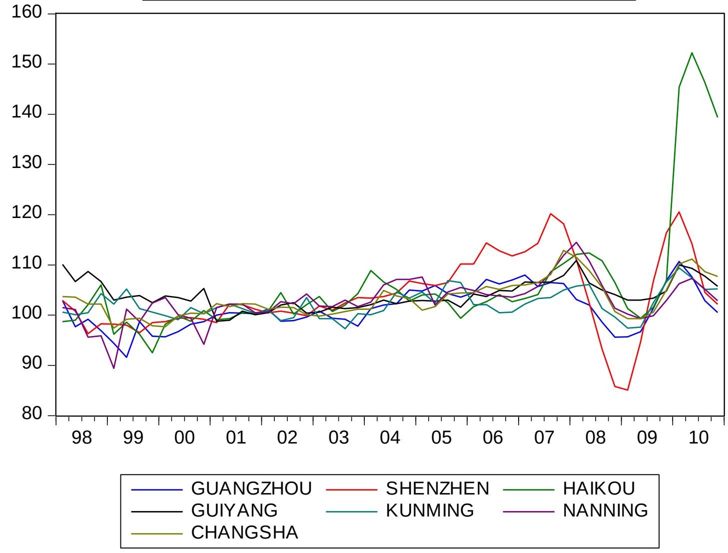


Figure 4.3: The Link Index of HPI of 35 Cities from 1998Q1 to 2010Q4

Figure 4.4: The Link Index of HPI of 35 Cities by Groups over 1998Q1-2010Q4







4.4.2 Data Transformation

There are several steps to revise the link index data (HPI) into a continuous price index:

(1) The first step is to find the most stable period (covering four quarters) for each city. Appendix 4.1 exhibits the link index of house prices and highlights the most stable four quarters for each city and the nation. The stable periods are stated in Table 4.4. Firstly, in the four quarters of stability, we make the assumption of annual price change equal to the constant growth of quarterly change (annual rate = (quarterly rate)^4), which means the link index is adjusted for quarterly rate. The underlying assumption is that if over a sustained period annual house price change is *x*, then the increase in any one quarter is proportional to *x*.

Then, if we say these quarters are '$\tau+1$, $\tau+2$, $\tau+3$, *and* $\tau+4$' (τ=1,2, …, 52, from 1998Q1 to

2010Q4), the calculation can be started from quarter *τ+1* by setting up the previous index equal to 100 (P_τ=100). So we get the adjusted index (P) for the stable quarters:

$$
\begin{aligned}
P_{\tau+1} &= P_{\tau} * (HPI_{\tau+1}/100)^{0.25} \\
P_{\tau+2} &= P_{\tau+1} * (HPI_{\tau+2}/100)^{0.25} \\
P_{\tau+3} &= P_{\tau+2} * (HPI_{\tau+3}/100)^{0.25} \\
P_{\tau+4} &= P_{\tau+3} * (HPI_{\tau+4}/100)^{0.25}
\end{aligned}
\tag{4.29}
$$

After this, the forward calculations are as follows:

$$
\begin{aligned}
P_{\tau+5} &= P_{\tau+1} * (HPI_{\tau+5}/100) \\
P_{\tau+6} &= P_{\tau+2} * (HPI_{\tau+6}/100) \\
&\vdots \\
P_{51} &= P_{47} * (HPI_{51}/100) \\
P_{52} &= P_{48} * (HPI_{52}/100)
\end{aligned}
\tag{4.30}
$$

Remember HPI is an index if house price increased by 10% over the previous 12 months, HPI=110. And the backward calculation is as follows:

$$
\begin{aligned}
P_{\tau-1} &= P_{\tau+3} * (100/HPI_{\tau+3}) \\
P_{\tau-2} &= P_{\tau+2} * (100/HPI_{\tau+2}) \\
&\vdots \\
P_{2} &= P_{6} * (100/HPI_{6}) \\
P_{1} &= P_{5} * (100/HPI_{5})
\end{aligned}
\tag{4.31}
$$

(2) After getting the adjusted index (P), the purpose of this exercise has been primarily to identify an index for the first four quarters. The following step is to use the first four quarters (1998Q1 to 1998Q4) as the base index to identify the more precise index (P^c), saying $P_1^c = P_1$, $P_2^c = P_2$, $P_3^c = P_3$, and $P_4^c = P_4$. The further index can be driven by:

$$
\begin{aligned}
P_5^c &= P_1^c * (HPI_5/100) \\
P_6^c &= P_2^c * (HPI_6/100) \\
P_7^c &= P_3^c * (HPI_7/100) \\
&\vdots \\
P_{52}^c &= P_{48}^c * (HPI_{52}/100)
\end{aligned}
\tag{4.32}
$$

(3) To make different cities' indices comparable, the final transformed index (HP) is to divide

all values by the index value of P^c in 1998Q1 (P_1^c) and then multiply by 100, which will ensure all indices are 100 in 1998Q1:

$$
\begin{aligned}
&HP_1 = (P_1^c / P_1^c) * 100 = 100 \\
&HP_2 = (P_2^c / P_1^c) * 100 \\
&HP_3 = (P_3^c / P_1^c) * 100 \\
&\vdots \\
&HP_{52} = (P_{52}^c / P_1^c) * 100
\end{aligned}
\tag{4.33}
$$

(4) Finally, the data set can be extended backwards to 1997 as well, based on the HPI link index in 1998, which will ensure no valid data has been omitted. The following equations show the generation of the final transformed index (HP) in 1997:

$$
\begin{aligned}
&HP_{97Q1} = (HP_{98Q1} / HPI_{98Q1}) * 100 \\
&HP_{97Q2} = (HP_{98Q2} / HPI_{98Q2}) * 100 \\
&HP_{97Q3} = (HP_{98Q3} / HPI_{98Q3}) * 100 \\
&HP_{97Q4} = (HP_{98Q4} / HPI_{98Q4}) * 100
\end{aligned}
\tag{4.34}
$$

After the above steps, the original link index of HPI has been revised into the constant growth house price index (HP) from 1997Q1 to 2010Q4. It will be recalled that the HPI gap is the difference between the highest HPI and the lowest HPI over a time period, and this is smallest during the stable period for each city. Table 4.4 lists the HPI gaps during the stable periods. It can be seen from Figure 4.5 that most cities have a relatively stable period with the link index (HPI) gap smaller than 1, especially for Beijing, Changchun and Tianjin with a 0.2 gap and Harbin, Taiyuan, Xi'an and Xiamen with a 0.3 gap. But some cities have been through a quite volatile period with the HPI gap higher than 1.5, for instance, 1.5 for Haikou and 1.6 for Kunming and Qingdao. As for the emerging coastal tourism cities of Haikou and Qingdao, the overheated tourist economy in certain periods is likely to cause their greater volatility of HPI changes.

The original link index is based on the same quarter of last year; for example, if HPI in the last quarter is 100 and the house price increased by 10% over the last 12 months, HPI in this quarter is 110. To transfer the link index into the constant growth index (the first period index=100), we made the assumption of annual price change in the stable four-quarter period equal to the constant growth of quarterly change (annual rate = (quarterly rate)^4), denoting the link index is adjusted for the quarterly rate.

Table 4.4: The Stable Period and the Index Difference after Adjustment

City Code	City	Stable Period (cover 4 quarters)	link index (HPI) gap during stable period	link index (HPI) at the last quarter of stable period	adjusted index (P) at the last quarter of stable period	the difference between link index (HPI) and adjusted index (P)
1	Beijing	2004Q4—2005Q3	0.2	106.3	106.4	0.1
2	Changchun	1998Q1—1998Q4	0.2	100.5	100.4	-0.1
3	Changsha	2006Q2—2007Q1	0.9	106	105.6744	-0.3256
4	Chengdu	1998Q3—1999Q2	0.5	105.8	105.5748	-0.2252
5	Chongqing	2001Q4—2002Q3	0.5	101.8	101.4998	-0.3002
6	Dalian	2007Q1—2007Q4	0.7	107.6	107.1747	-0.4253
7	Fuzhou	1998Q3—1999Q2	0.7	101.4	101.1495	-0.2505
8	Guangzhou	2001Q1—2001Q4	0.5	100.3	100.2998	-0.0002
9	Guiyang	2004Q3—2005Q2	0.6	102.8	102.6997	-0.1003
10	Haikou	2001Q2—2002Q1	1.5	100.8	100.2484	-0.5516
11	Hangzhou	2006Q2—2007Q1	0.7	102.9	102.8997	-0.0003
12	Harbin	2002Q4—2003Q3	0.3	100	99.99992	-8E-05
13	Hefei	2001Q1—2001Q4	0.5	100.4	100.4748	0.0748
14	Hohhot	2007Q1—2007Q4	0.5	104.6	104.3498	-0.2502
15	Jinan	1998Q2—1999Q1	0.5	101.6	101.4498	-0.1502
16	Kunming	2006Q1—2006Q4	1.6	100.6	101.322	0.722
17	Lanzhou	2005Q2—2006Q1	0.6	105.6	105.4498	-0.1502
18	Nanchang	2006Q3—2007Q2	0.9	106.7	106.3243	-0.3757
19	Nanjing	2006Q1—2006Q4	1.0	104.7	104.3492	-0.3508
20	Nanning	2006Q2—2007Q1	0.7	104.3	103.9497	-0.3503
21	Ningbo	2006Q1—2006Q4	0.9	102.2	102.1495	-0.0505
22	Qingdao	2006Q3—2007Q2	1.6	105.9	105.9985	0.0985
23	Shanghai	1999Q4—2000Q3	0.8	97.8	98.37443	0.57443
24	Shenyang	1998Q3—1999Q2	0.5	101.8	101.7248	-0.0752
25	Shenzhen	2002Q1—2002Q4	0.9	99.9	100.3995	0.4995
26	Shijiazhuang	1999Q1—1999Q4	0.6	103.3	103.7247	0.4247
27	Taiyuan	2002Q1—2002Q4	0.3	103.4	103.3249	-0.0751
28	Tianjin	2000Q1—2000Q4	0.2	100	99.94996	-0.05004
29	Urumchi	2001Q1—2001Q4	0.5	100.7	100.9497	0.2497
30	Wuhan	2006Q2—2007Q1	0.4	103.2	103.0499	-0.1501
31	Xi'an	2002Q3—2003Q2	0.3	101.1	101.1999	0.0999
32	Xiamen	2002Q4—2003Q3	0.3	102.4	102.4249	0.0249
33	Xining	2006Q3—2007Q2	0.8	103	102.6246	-0.3754
34	Yinchuan	2005Q4—2006Q3	0.7	102.4	102.2747	-0.1253
35	Zhengzhou	2001Q1—2001Q4	0.6	100.8	100.5747	-0.2253
Nation		2006Q2—2007Q1	0.4	105.6	105.5249	-0.0751

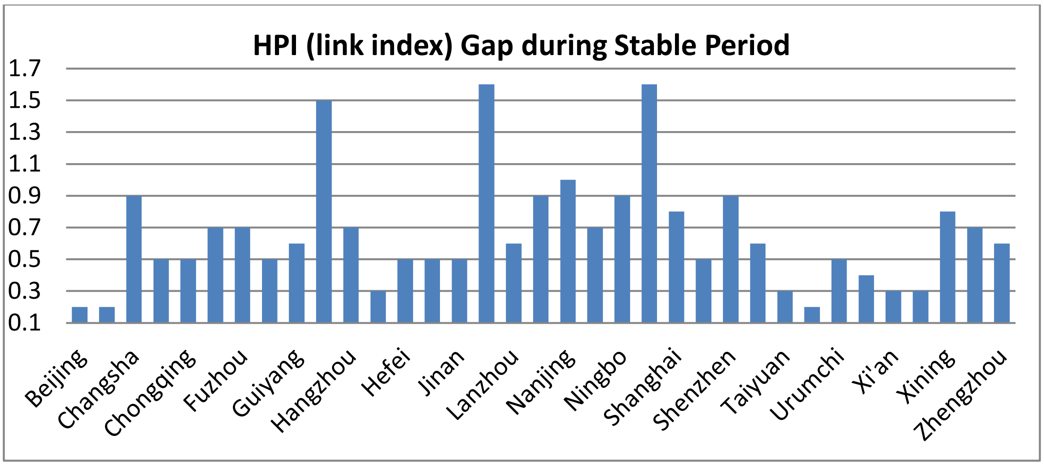


Figure 4.5: Link Index (HPI) Gap during Stable Period

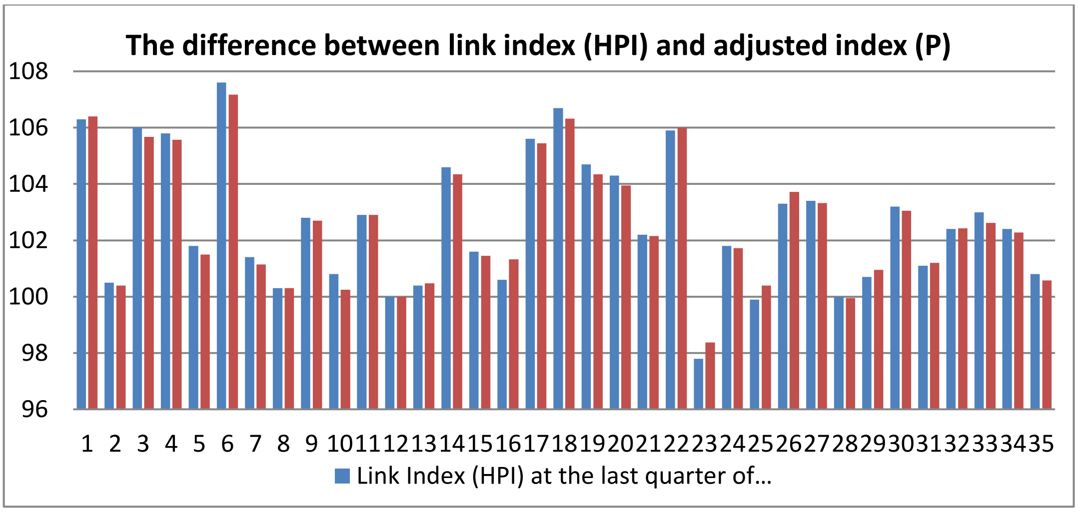
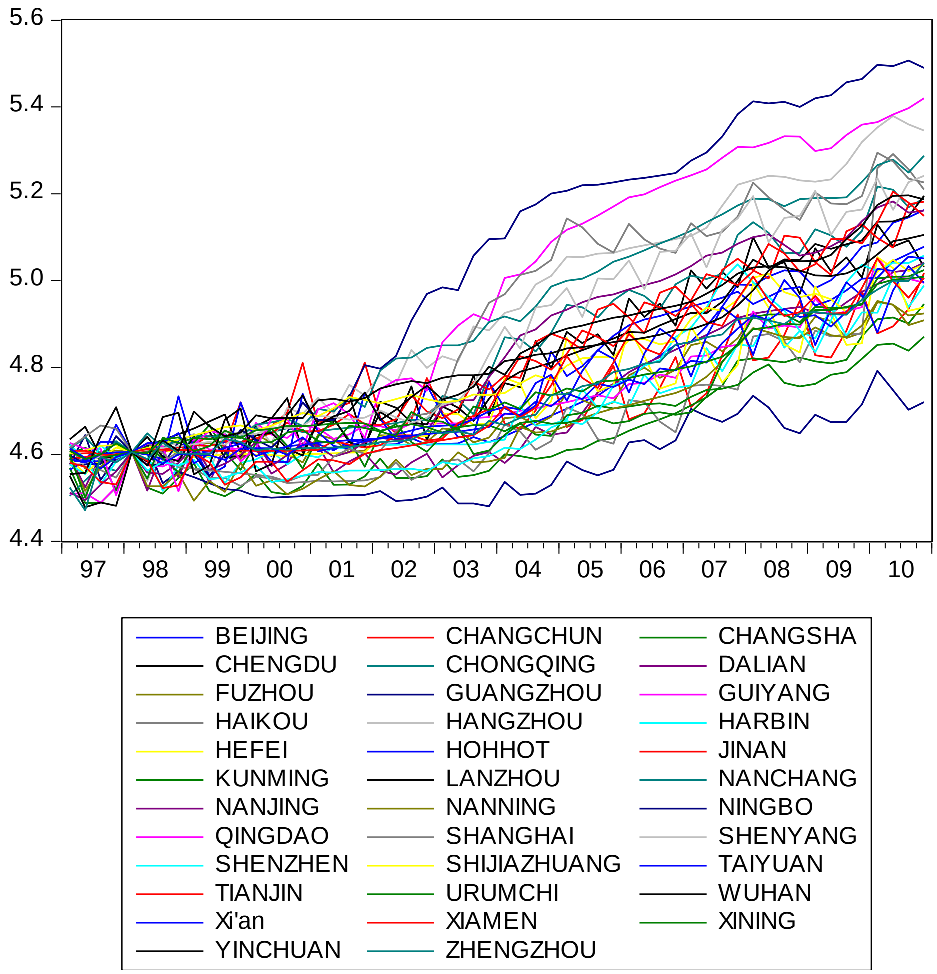


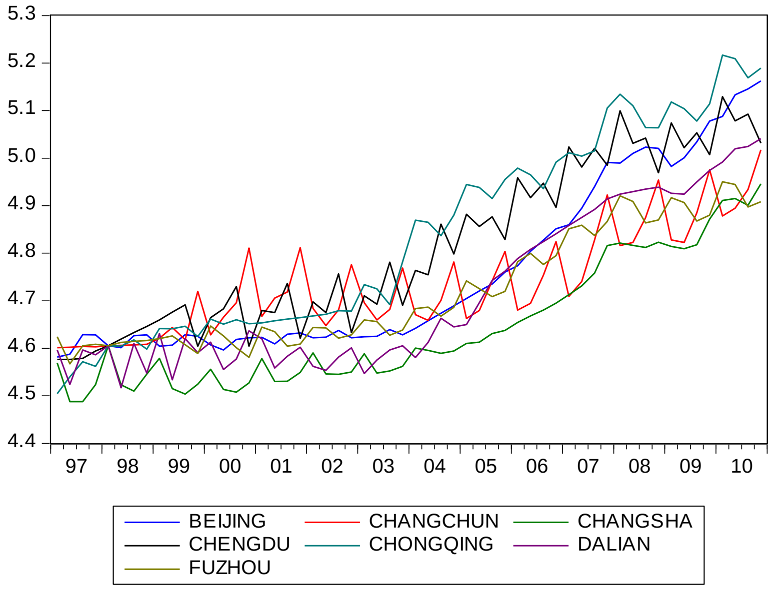
Figure 4.6: The Difference Between Link Index (HPI) and Adjusted Index (P)

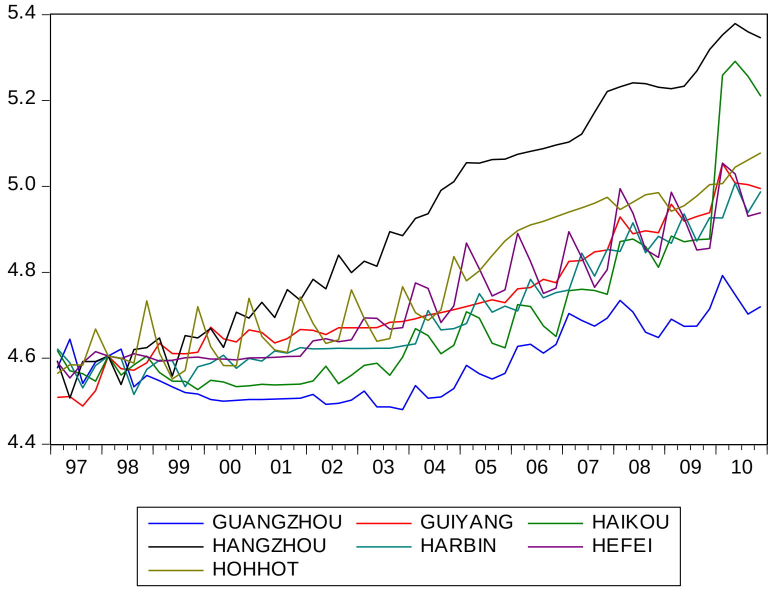
Therefore, in order to estimate the efficiency of our assumption in the first step, Table 4.4 compares the link index (HPI) with the adjusted index (P) at the last quarter of the stable period. Figure 4.6 exhibits more straightforwardly the difference by drawing a bi-column chart and shows our estimated index (P) very close to the original index (HPI) for all the cities. The underlying assumption is that if annual house price change is *x* over a sustained period, then the increase in any one quarter is proportional to *x*. The column graph verifies our assumption is valid and efficient.

After transferring the original link index (HPI) into the constant growth index (HP), we can display the logarithm of new transferred house price indices for each city over 1997Q1 to 2010Q4 in the following Figure 4.7. It can be seen that, although the intensities of their fluctuations differ from each other, overall there is an upward trend for all the cities, which implies the house prices across China have been through sustained growth over this decade. For instance, Ningbo and Qingdao (the top two lines) have apparently exhibited the most rapid ascending tendency since 2002. More specifically, since then the house price indices of Ningbo and Qingdao have maintained a higher level than the other cities. Because both cities are municipalities with independent planning status (J*i Hua Dan Lie Shi*), the strong motivation of economic development has contributed the fast growth of their house prices. By contrast, Guangzhou (the bottom line) has the lowest growth rate during this period, and its house price index has fluctuated around 4.6 with the lightly upward trend.

Figure 4.7: The Log of Transferred House Price (HP) Indices




5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
97 98 99 00 01 02 03 04 05 06 07 08 09 10
BEIJING
CHANGCHUN
CHANGSHA
CHENGDU
CHONGQING
DALIAN
FUZHOU


5.4
5.2
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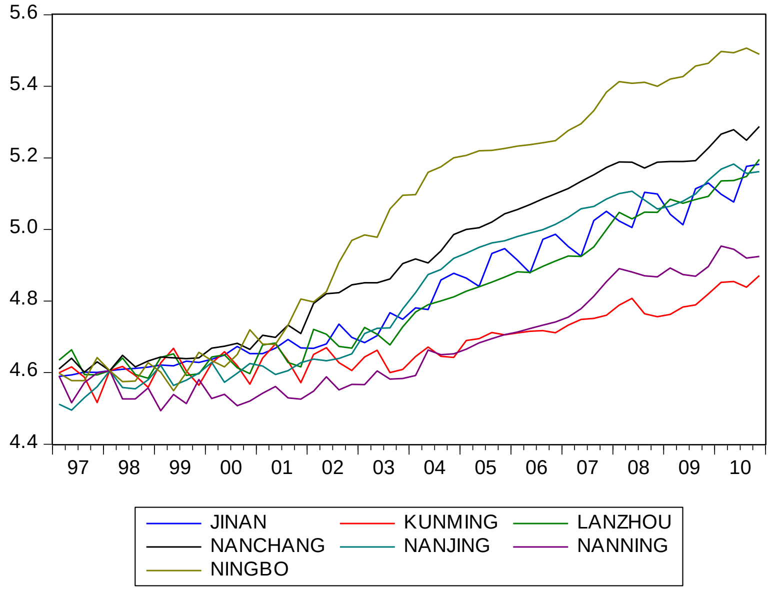
97 98 99 00 01 02 03 04 05 06 07 08 09 10
GUANGZHOU
GUIYANG
HAIKOU
HANGZHOU
HARBIN
HEFEI
HOHHOT


5.6
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NANJING
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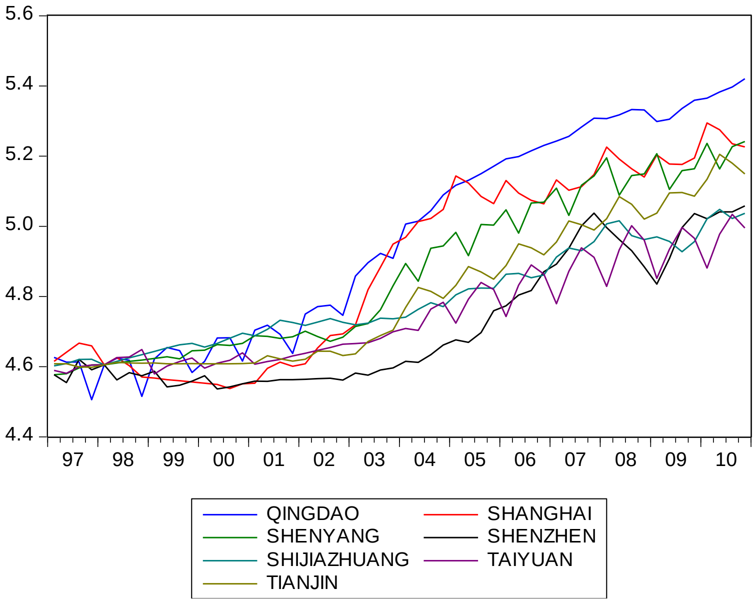
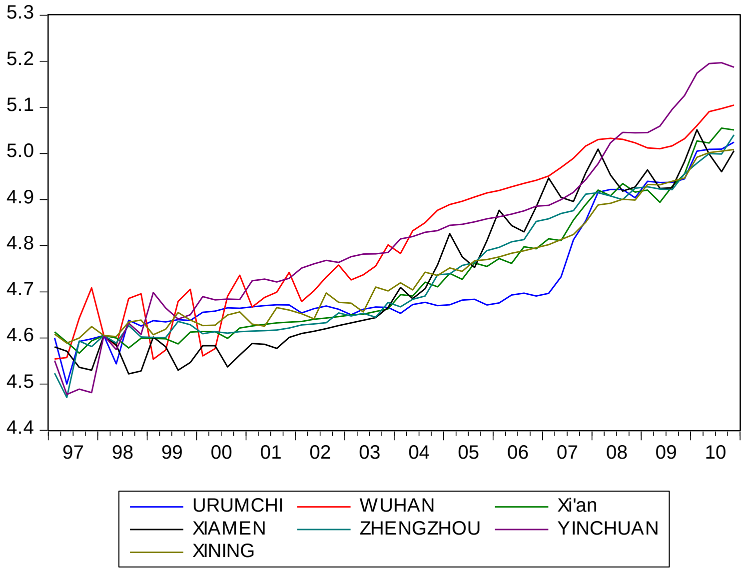
NINGBO





It is also worth drawing our attention to the fact that, all above tests we applied—the unit root tests, the cointegration tests and the causality tests—contain a starting model we need to choose, i.e specify either a constant or constant & trend. As Figure 4.7 displayed, generally there is an upward trend in the regional house prices over the decade; thus necessarily, the significance of the trend needs to be tested further. Table 4.5 illustrates the significance test for regional house price indices; and there is strong evidence of all the cities having a significant trend at the 1% level. Consequently, for the above mentioned tests we are going to choose the constant & trend model.

Table 4.5: Tests of the Significance of the Trend for House Price Indexes of Each City

The Significance Test of the Trend for Each City					
Explanatory variable Trend for each city	Coefficient	p-value	Explanatory variable Trend for each city	Coefficient	p-value
Beijing	0.010 (15.50)	0.000***	Nanjing	0.014 (30.40)	0.000***
Changchun	0.006 (11.60)	0.000***	Nanning	0.008 (16.77)	0.000***
Changsha	0.007 (15.59)	0.000***	Ningbo	0.020 (36.22)	0.000***
Chengdu	0.010 (22.55)	0.000***	Qingdao	0.018 (31.40)	0.000***
Chongqing	0.013 (31.55)	0.000***	Shanghai	0.015 (18.82)	0.000***
Dalian	0.009 (15.32)	0.000***	Shenyang	0.014 (28.87)	0.000***
Fuzhou	0.007 (18.28)	0.000***	Shenzhen	0.010 (14.11)	0.000***
Guangzhou	0.004 (7.11)	0.000***	Shijiazhuang	0.008 (32.14)	0.000***
Guiyang	0.008 (24.90)	0.000***	Taiyuan	0.008 (20.16)	0.000***
Haikou	0.009 (9.85)	0.000***	Tianjin	0.012 (22.69)	0.000***
Hangzhou	0.016 (49.24)	0.000***	Urumchi	0.007 (12.87)	0.000***
Harbin	0.008 (18.33)	0.000***	Wuhan	0.010 (27.16)	0.000***
Hefei	0.008 (16.73)	0.000***	Xi'an	0.008 (21.08)	0.000***
Hohhot	0.009 (19.27)	0.000***	Xiamen	0.010 (22.28)	0.000***
Jinan	0.011 (29.34)	0.000***	Xining	0.007 (23.69)	0.000***
Kunming	0.005 (15.62)	0.000***	Yinchuan	0.011 (30.92)	0.000***
Lanzhou	0.011 (23.91)	0.000***	Zhengzhou	0.009 (24.80)	0.000***
Nanchang	0.014 (46.03)	0.000***	-	-	-
Note: ( ) denotes the t statistics of the respective coefficients. ***, ** and * indicate significance at 1%, 5% and 10% level respectively.					

4.5 Empirical Results

4.5.1 Results of Unit Root Tests

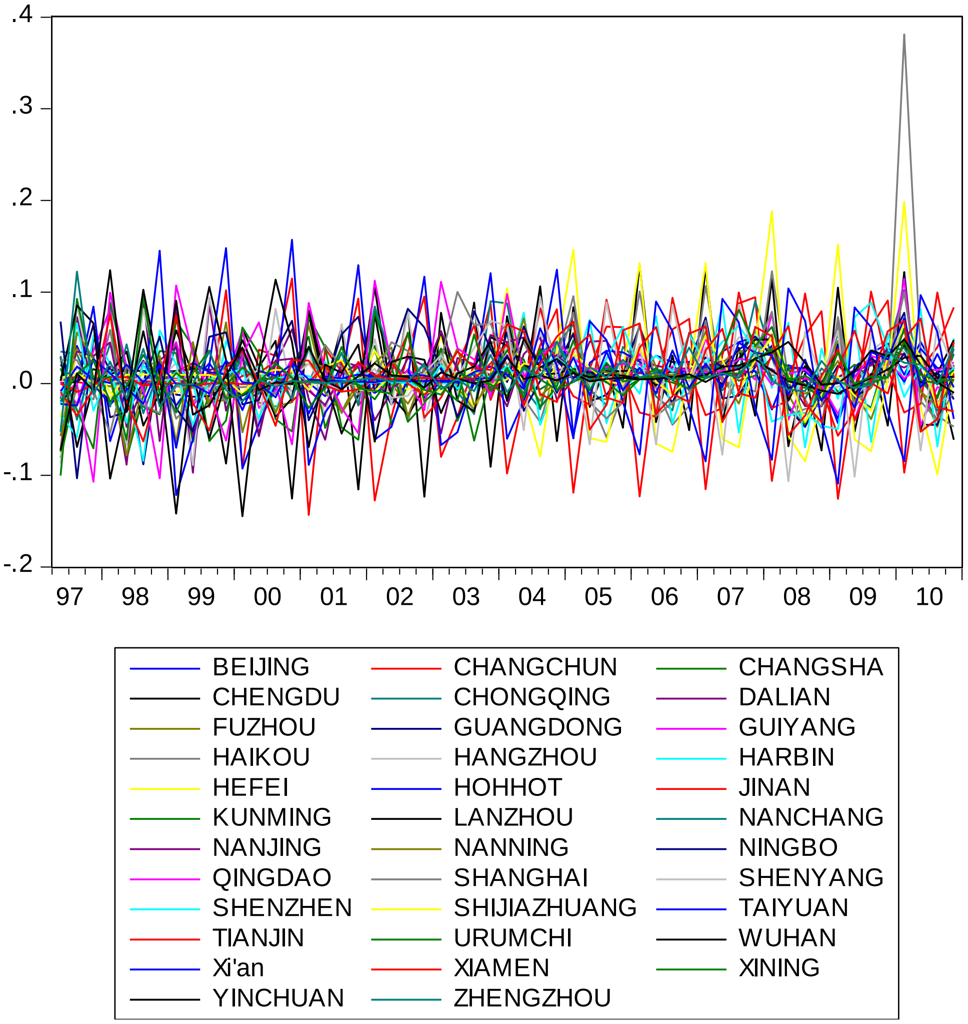
4.5.1.1 Unit Root Test Results for House Price Index

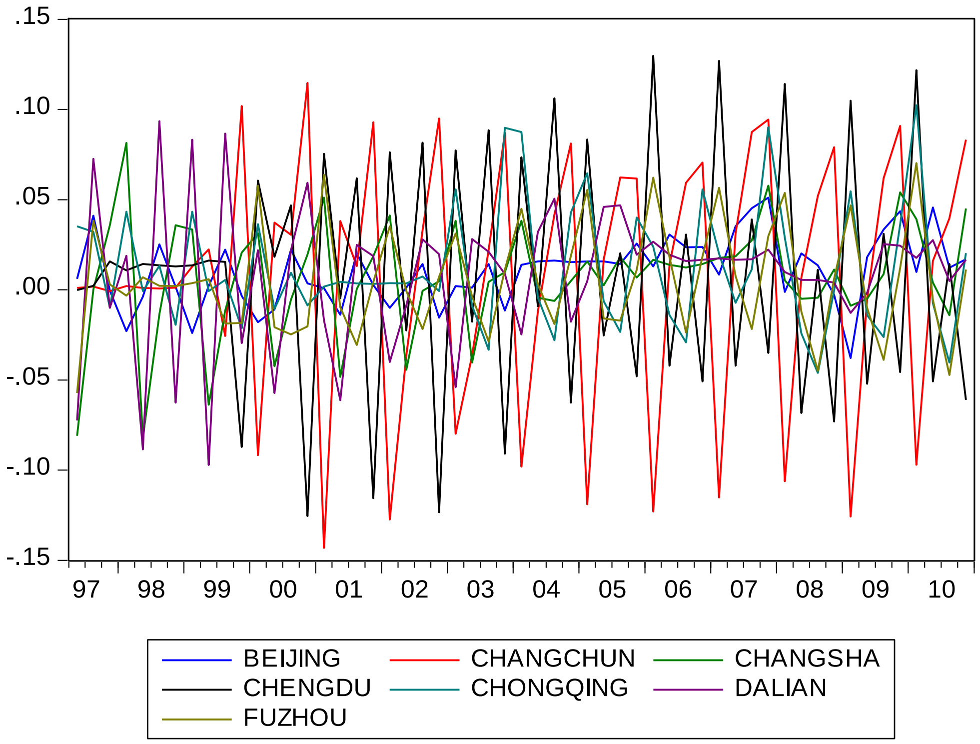
For the following tests and regressions, we adopt the logarithm format of final transformed index (LHP). The stationarity of regional house price indices need to be identified prior to the following stochastic techniques, such as the cointegration tests, the panel regression models and Granger causality tests; for instance, as mentioned in the methodology, Engle-Granger cointegration tests need all data series to be I(1), but the panel regression models and Granger causality tests need the series to be stationary.

Firstly, the stationarity for each city is tested by the univariate ADF test; moreover, the Dickey-Fuller GLS (DF-GLS) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are introduced to support the evidence of the ADF test. Appendix 4.2 shows us the univariate unit root tests' results for LHP. As explained before, the unit root tests will determine the starting model with 'intercept and trend'. Because our data are quarterly data, the ADF tests take the lag length suggested by SIC, and this suggests a lag of 4 for most cities, except for several cities chosen with more than 4 lags. Hence, we will fix the lag length at 4 for DF-GLS tests and KPSS tests later, in order not to reduce using too many degrees of freedom. Appendix 4.2 demonstrates that for ADF tests, no matter whether the lag length has been decided by SIC or fixed at 4, the concordant results suggest that all the cities' house prices are non-stationary by failing to reject the null. As for the ADF test, the null hypothesis of the DF-GLS test is 'has a unit root' as well, but the null hypothesis of KPSS test is 'no unit root or stationary'. The conclusions of failing to reject the null of the DF-GLS tests and strongly rejecting the null of KPSS tests, are consistent with the ADF tests. As a complement to the unit root tests with the trend, Appendix 4.3 shows the tests without a 'trend'. Again, all the tests come to the same conclusion with strong evidence of non-stationarity.

In short, the house prices in 35 cities have a unit root and are not stationary over 1997Q1 to 2010Q4. However, the implementation of panel regression models and Granger causality tests needs the variables to be stationary. So the first difference of LHP (DLHP) has been tested by ADF tests as well in Appendix 4.2. The lag length for testing DLHP is decided by SIC, as SIC usually chose less than a lag of 4, which means it is unnecessary to lose more degrees of freedom by fixing at lag 4. The results illustrate that most series are I(1) at the 10% level and rarely cities are I(2), such as Dalian, Jinan, Ningbo, Qingdao, Shenyang and Zhengzhou. As we can see from Figure 4.8, except for Haikou, the first differences of other cities' house prices have fluctuated within a certain band (-0.2~0.2), which implies their first differences have a stationary trend.

Figure 4.8: The Graph of the 1st Difference of House Prices (DLHP)

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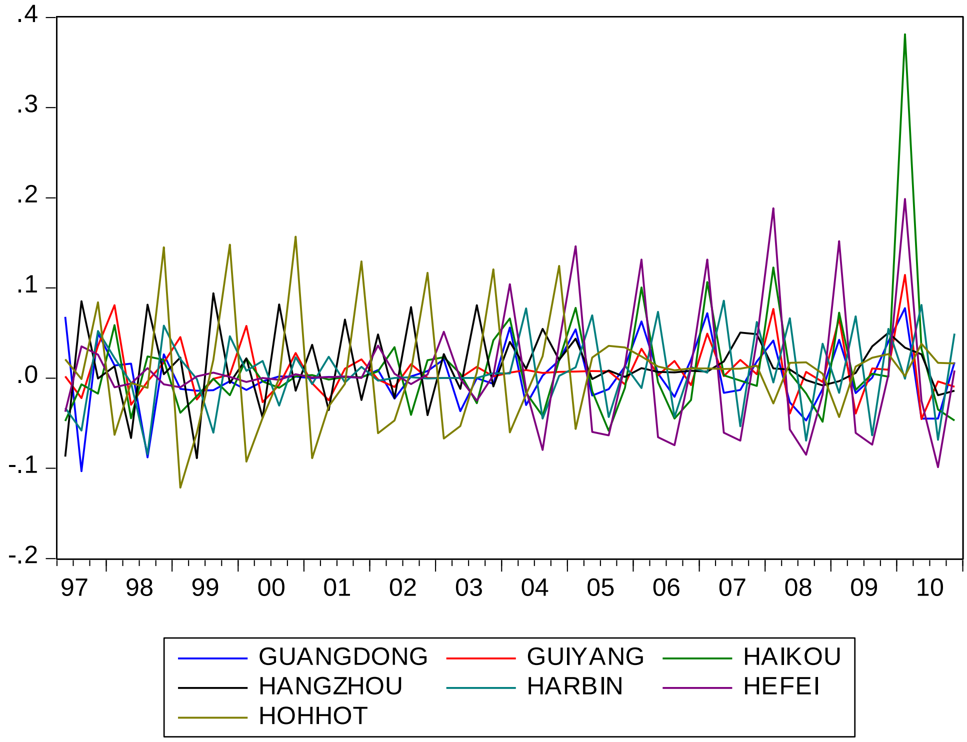
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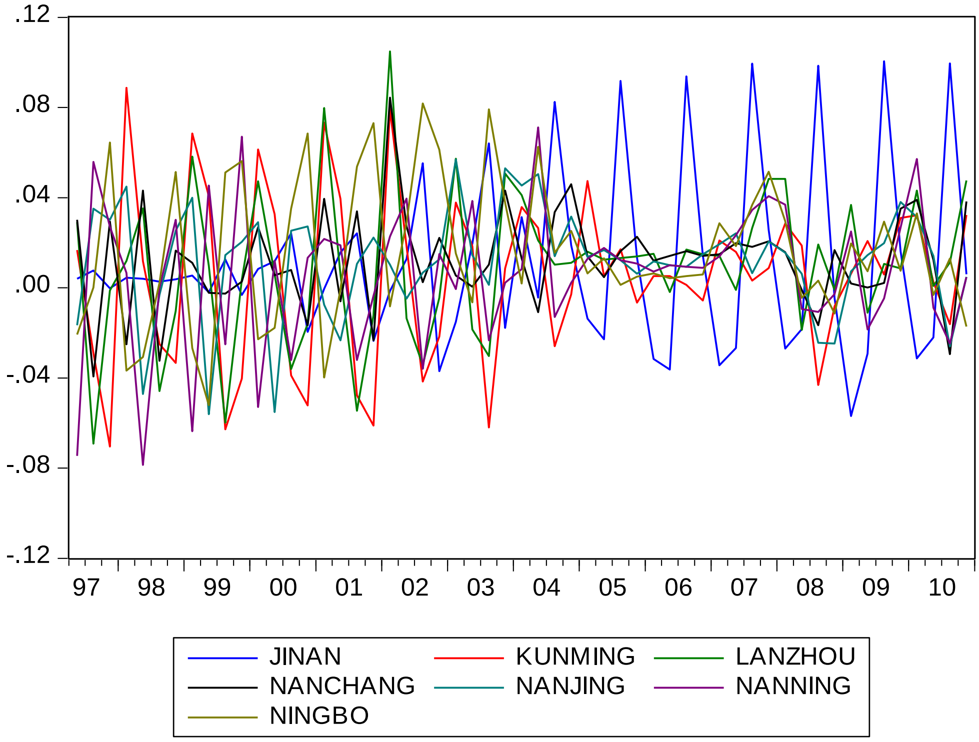

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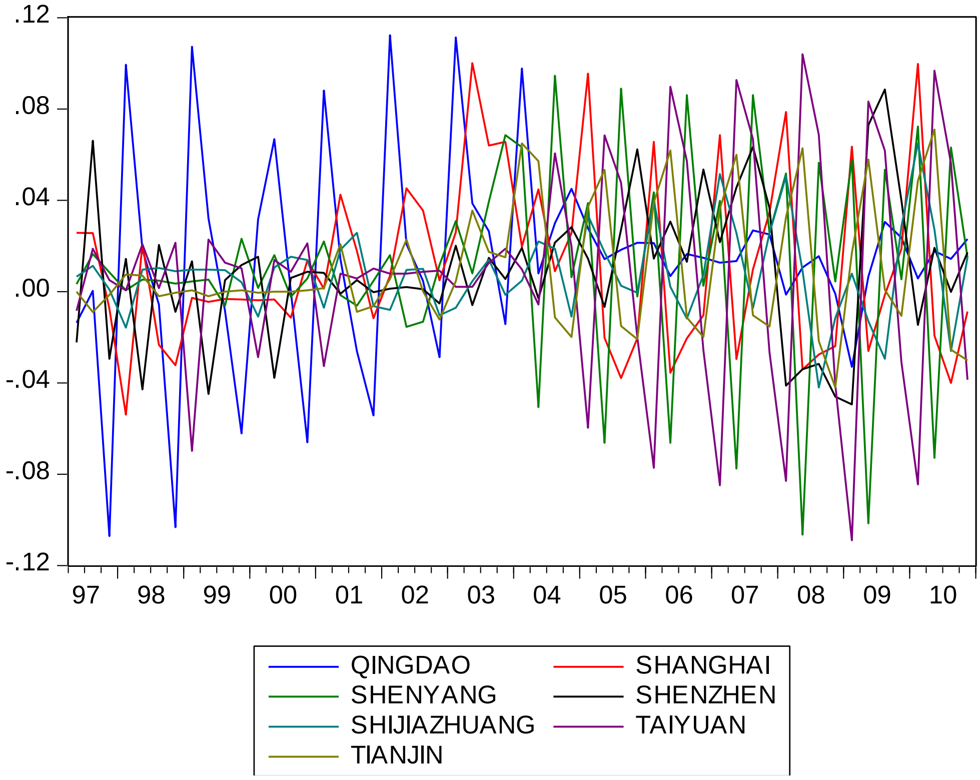

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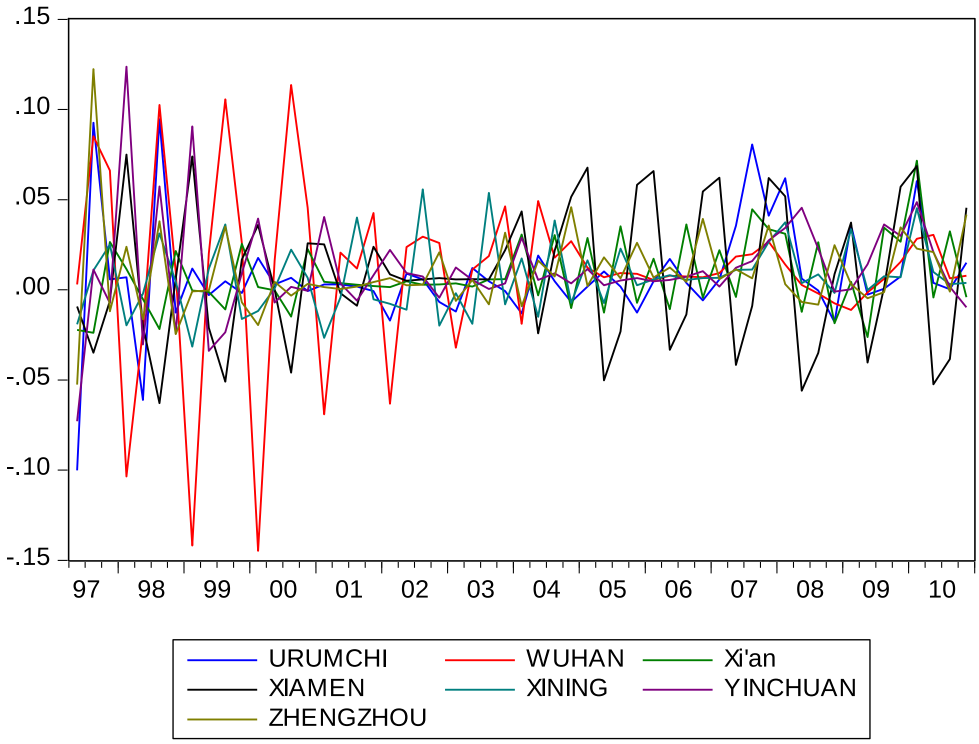


Next, the panel unit root tests for LHP and DLHP show the evidence of further divergence. Table 4.6 summarises the results from the panel unit root tests. Except for the Hadri test, the null of other tests indicate the existence of unit root; while the null of the Hadri test is 'all panels are stationary'. Whether the lag length is specified by SIC or fixed at lag 4 has no effects on the results; even in the tests for DLHP, SIC also chose the lag of 4. As explained before, unit root tests for LHP are with the trend, while unit root tests for DLHP are without the trend, as there is no sign of a trend for DLHP in Figure 4.8. Levin, Lin & Chu (LLC) test, Im, Pesaran & Shin (IPS) test, ADF test and PP test all strongly fail to reject the null testing LHP and reject the null testing DLHP at 1% significant level; conversely, the Hadri test strongly rejects the null testing LHP and fail to reject the null testing DLHP. In short, all the results suggest the same conclusion of non-stationary LHP and stationary of DLHP.

Table 4.6: Panel Unit Root Tests for LHP and DLHP

Panel Unit Root Test	**LHP (with trend)**			**LHP (with trend)**			**DLHP (without trend)**		
	Lags by SIC (lag 5)			**Lags Fixed at 4**			**Lags by SIC (lag 4)**		
	Statistic	Prob.	Fail to reject or Reject	Statistic	Prob.	Fail to reject or Reject	Statistic	Prob.	Fail to reject or Reject
Method	Cross-sections: 35			Cross-sections: 35			Cross-sections: 35		
Levin, Lin & Chu (H_0: Unit root (assumes common unit root	-0.02402	0.4904	**Fail to reject**	9.61230	1.0000	**Fail to reject**	-4.52161	0.0000***	**Reject**

process))										
H_0: Unit root (assumes individual unit root process)	Im, Pesaran and Shin	7.32365	1.0000	**Fail to reject**	4.42551	1.0000	**Fail to reject**	-14.8167	0.0000***	**Reject**
	ADF – Fisher	5.05284	1.0000	**Fail to reject**	13.1525	1.0000	**Fail to reject**	330.121	0.0000***	**Reject**
	PP – Fisher	1.49736	1.0000	**Fail to reject**	1.49736	1.0000	**Fail to reject**	775.607	0.0000***	**Reject**
Method		Cross-sections: 35 Periods: 56						Cross-sections: 35 Periods: 55		
Hadri (H_0: All panels are stationary)		23.1532		0.0000***		**Reject**		-2.2181	0.9867	**Fail to reject**

Note:
(1) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.
(2) The lag specification of tests for LHP by SIC: 5.
(3) The lag specification of tests for DLHP by SIC: 4.
(4) Tests for LHP with trend.
(5) Tests for DLHP without trend.

In short, both the univariate unit root tests and the panel unit root tests manifest that the regional house price index is not stationary; hence, it can be directly used for Engle-Granger cointegration tests, but the difference format of LHP needs to be introduced into the panel regression models and Granger causality tests.

4.5.1.2 Unit Root Test Results for Regional-national House Price Ratios

As the literature review mentioned before, Drake (1995) and Cook (2003) employ the regional-national house price ratios (HPR) to test for convergence. So we create the regional-national house price ratio to test for convergence between the regional index and the national index. The original link index of national house price (HPI_n) can be modified by the above method, and we get the final constant house price index (HP_n) for the nation. To create house price ratios, the logarithm of national house price index (HP_n) is subtracted from the logarithm for a given city (HP_i, i=1, 2, …, 35 representing the city code). The new house price ratios ($HPR_{i,\tau}$) cover between 1997Q1 and 2010Q4 and it can be expressed as following:

$$HPR_{i,\tau} = \ln(HP_{i,\tau} / HP_{n,\tau}) = \ln HP_{i,\tau} - \ln HP_{n,\tau} \quad (4.35)$$

Rewrite as in Equation 4.25, $\ln HP_{i,\tau} = \alpha + \beta \ln HP_{n,t} + e_t$, hence testing the stationary of 35 ratios is equivalent to assuming β =1. Under the assumption of β =1, we can get $\ln HP_{i,\tau} = \alpha + \ln HP_{n,t} + e_t$, which means $\ln HP_{i,\tau} - \ln HP_{n,t} = \alpha + e_t$; thereby we have

$HPR_{i,t} = \ln(HP_{i,t}/HP_{n,t}) = \ln HP_{i,\tau} - \ln HP_{n,t} = \alpha + e_t$. If $\alpha + e_t$ is stationary, then $HPR_{i,t}$ is stationary as well. Again, the two tests are the same but for the further restriction $\beta = 1$.

We investigate the convergence of house price ratios by univariate unit root tests and panel unit root tests, which results are stated in Table 4.7 and Table 4.8 respectively. Again, the lag specification by SIC is 4 for most cities, which means lag 4 is an efficient lag length; thus DF-GLS tests and KPSS tests use the fixed lag length of 4. Also, due to the significance of the time trend, the unit root tests for regional-national house price ratios choose the starting model with 'constant and trend'. Table 4.7 illustrates that all the house price ratios are non-stationary by ADF tests at the 5% level. Only Guangzhou and Shenzhen house price ratios show convergence under the DF-GLS test at 5% significance level; however, under the KPSS test, more cities' house price ratios show stationarity at the 5% significance levels, such as Chengdu, Fuzhou, Guangzhou, Harbin, Hohhot, Lanzhou, Xiamen and Zhengzhou. But overall, most of results do not support evidence of convergence in China's regional-national house price ratios.

Table 4.7: Univariate Unit Root Tests of HPR

City Code	City	ADF Test by SIC			ADF Test by Fixed Lag 4		DF-GLS test	KPSS test
		t-Statistic	Prob.	Lag Length	t-Statistic	Prob.	t-Statistic	LM-Stat.
1	Beijing	-1.893243	0.6435	4	-	-	-2.250672	0.246496***
2	Changchun	-2.434184	0.3584	4	-	-	-1.814179	0.157664**
3	Changsha	-1.394536	0.8509	4	-	-	-1.548639	0.160865**
4	Chengdu	-2.017661	0.5781	3	-2.425224	0.3628	-1.642507	0.136816*
5	Chongqing	-2.344234	0.4034	4	-	-	-1.367169	0.154474**
6	Dalian	-1.774627	0.7024	4	-	-	-1.727027	0.185916**
7	Fuzhou	-2.777474	0.2120	4	-	-	-2.843284	0.094290
8	Guangzhou	-3.387076	0.0644	4	-	-	-3.441039**	0.136335*
9	Guiyang	-2.047554	0.5618	4	-	-	-1.845631	0.155765**
10	Haikou	2.316334	1.0000	5	1.802900	1.0000	-1.003652	0.197143**
11	Hangzhou	-1.271743	0.8837	4	-	-	-1.736947	0.270580***
12	Harbin	-1.946324	0.6158	4	-	-	-2.051343	0.129576*
13	Hefei	-2.500032	0.3269	4	-	-	-2.116501	0.193739**
14	Hohhot	-2.678221	0.2496	4	-	-	-2.132987	0.097286
15	Jinan	-2.562884	0.2983	4	-	-	-2.136739	0.153752**
16	Kunming	-2.623823	0.2720	4	-	-	-1.786141	0.176692**
17	Lanzhou	-2.114312	0.5256	4	-	-	-2.118703	0.130446*
18	Nanchang	-0.931730	0.9441	4	-	-	-1.352802	0.262906***
19	Nanjing	-0.616801	0.9736	4	-	-	-1.125316	0.203061**
20	Nanning	-2.706985	0.2384	5	-2.209359	0.4772	-1.363444	0.150647**

21	Ningbo	-1.952125	0.6128	4	-	-	-2.461857	0.222354***
22	Qingdao	-0.627763	0.9729	4	-	-	-1.540238	0.205067**
23	Shanghai	-2.400139	0.3752	4	-	-	-2.490258	0.157000**
24	Shenyang	-2.547250	0.3053	4	-	-	-2.676437	0.152533**
25	Shenzhen	-1.619418	0.7711	5	-3.507194	0.0492	-3.242649**	0.174065**
26	Shijiazhuang	-3.329056	0.0731	4	-	-	-2.565654	0.184001**
27	Taiyuan	-3.174152	0.1011	4	-	-	-2.238615	0.154977**
28	Tianjin	-2.008064	0.5822	7	-3.496234	0.0505	-2.711303	0.195024**
29	Urumchi	-2.305434	0.4234	4	-	-	-2.377961	0.148377**
30	Wuhan	-1.274659	0.8830	4	-	-	-0.848555	0.285741***
31	Xi'an	-1.270541	0.8840	4	-	-	-1.662644	0.152189**
32	Xiamen	-0.665801	0.9702	4	-	-	-1.485815	0.141056*
33	Xining	-1.666239	0.7528	0	-2.428344	0.3612	-2.238259	0.147014**
34	Yinchuan	-2.979474	0.1479	4	-	-	-2.554824	0.164514**
35	Zhengzhou	-2.594804	0.2844	7	-2.704161	0.2394	-1.926236	0.127848*

Notes:
(1) The null of ADF and DF-GLS tests is 'unit root', the null of KPSS test is 'stationary'.
(2) All the tests choose the model with 'intercept and trend'.
(3) The ADF tests take the lag by both SIC and fixed lag 4.
(4) The DF-GLS and KPSS tests take the fixed lag 4.
(5) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.

As introduced in the methodology, compared with the univariate unit root tests, the efficiency of estimation can be improved by the panel unit root tests. Similarly, the lag length is specified by SIC at lag 4 again, and the tests are all with the 'constant and trend' model. Table 4.8 demonstrates same conclusions with the tests for the house price index. Both failing to reject the null of LLC, IPS, ADF and PP tests and rejecting the null of Hadri tests indicate there is unit root in house price ratios. Therefore, all the panel unit roots indicate the phenomenon of non-convergence between China's regional house price and the national house price.

Table 4.8: Panel Unit Root Tests of HPR

Panel Unit Root Test		**House Price Ratio (HPR)**		
		Statistic	**Prob.**	**Reject or Fail to reject**
Method		Lags by SIC: 4 Cross-sections: 35		
Levin, Lin & Chu (H_0: Unit root (assumes common unit root process))		-0.9481	0.1715	**Fail to reject**
H_0: Unit root (assumes individual unit root process)	Im, Pesaran and Shin	1.40407	0.9199	**Fail to reject**
	ADF – Fisher	30.8593	1.0000	**Fail to reject**
	PP – Fisher	1.76404	1.0000	**Fail to reject**
Method		Cross-sections: 35 Periods: 56		
Hadri (H_0: All panels are stationary)		16.9990	0.0000***	**Reject**
Note:				

(1) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.
(2) The lag specification of tests for LHP by SIC: 4.
(3) All tests with 'intercept and trend'.

4.5.1.3 Unit Root Test Results for Convergence within 'Clubs'

The above unit root test results demonstrate there is no evidence for regional house price indices converging to the national index; in order to test the convergence within 'clubs', the panel unit root tests are employed for house price ratios by using each city as the benchmark city. As shown in Equation 4.35, the house price ratio is expressed as: $HPR_{i,\tau} = \ln(HP_{i,\tau} / HP_{Benchmark,\tau}) = \ln HP_{i,\tau} - \ln HP_{Benchmark,\tau}$, where HP_i is the house price index in other city and $HP_{Benchmark}$ is the house price index in benchmark city; thus, every city will be used as benchmark city. If the house price ratio passes the panel unit root tests, there is evidence for convergence between the benchmark city and other cities. Table 4.9 summaries the panel unit root tests for each house price ratio. Once again, since there is no significant difference between the SIC lag specification and fixed lag of 4, so the panel unit root tests use lags of 4 with the trend. We can see that only a few house price ratios, based on Beijing, Shanghai, Shenzhen, Urumchi and Yinchuan, pass all three tests and show the stationarity. In another words, within 'clubs', there is evidence of other cities' house prices converging to the house prices of Beijing, Shanghai, Shenzhen, Urumchi and Yinchuan.

Table 4.9: Panel Unit Root Tests for House Price Ratios Based on Different Benchmark City

Benchmark City	H_0: Unit root (assumes common unit root process))		H_0: Unit root (assumes individual unit root process)			
	Levin, Lin & Chu		Im, Pesaran and Shin		ADF-Fisher	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Beijing	-7.50256	0.0000***	-7.04588	0.0000***	151.627	0.0000***
Changchun	-2.82453	0.0024***	0.57790	0.7183	36.7552	0.9993
Changsha	9.22421	1.0000	5.36079	1.0000	9.36949	1.0000
Chengdu	11.1665	1.0000	12.3391	1.0000	0.82015	1.0000
Chongqing	1.13248	0.8713	5.67350	1.0000	8.49252	1.0000
Dalian	9.76869	1.0000	4.55312	1.0000	12.0460	1.0000
Fuzhou	16.6876	1.0000	15.4277	1.0000	0.22060	1.0000
Guangzhou	11.6040	1.0000	8.21499	1.0000	3.72458	1.0000
Guiyang	-5.96016	0.0000***	-0.83515	0.2018	50.9463	0.9329
Haikou	19.9502	1.0000	5.93490	1.0000	7.81949	1.0000
Hangzhou	2.05449	0.9800	5.96285	1.0000	7.75057	1.0000
Harbin	7.33834	1.0000	5.26960	1.0000	9.64115	1.0000
Hefei	-2.53085	0.0057***	0.08368	0.5333	41.3845	0.9955
Hohhot	3.79790	0.9999	7.49475	1.0000	4.73320	1.0000
Jinan	1.92534	0.9729	4.62603	1.0000	11.7781	1.0000
Kunming	-2.26567	0.0117**	2.30296	0.9894	23.4003	1.0000

Lanzhou	5.75892	1.0000	2.83578	0.9977	20.1261	1.0000
Nanchang	4.69374	1.0000	9.75530	1.0000	2.18282	1.0000
Nanjing	2.08060	0.9813	5.05946	1.0000	10.2955	1.0000
Nanning	17.1910	1.0000	11.6827	1.0000	1.06202	1.0000
Ningbo	-5.32260	0.0000***	0.42833	0.6658	38.1174	0.9987
Qingdao	3.95924	1.0000	4.71452	1.0000	11.4599	1.0000
Shanghai	-8.78960	0.0000***	-4.15884	0.0000***	95.6734	0.0151**
Shenyang	-0.90768	0.1820	1.42539	0.9230	29.6546	1.0000
Shenzhen	-1.69713	0.0448**	-4.68747	0.0000***	104.186	0.0031***
Shijiazhuang	-4.66157	0.0000***	3.87941	0.9999	14.7971	1.0000
Taiyuan	7.28040	1.0000	9.14160	1.0000	2.71125	1.0000
Tianjin	-1.22229	0.1108	-1.45709	0.0725*	58.1237	0.7978
Urumchi	-15.8944	0.0000***	-5.86844	0.0000***	124.492	0.0000***
Wuhan	2.25585	0.9880	7.63923	1.0000	4.51323	1.0000
Xi'an	-4.02224	0.0000***	-1.12522	0.1302	54.2215	0.8876
Xiamen	15.6656	1.0000	13.5225	1.0000	0.50539	1.0000
Xining	-12.4305	0.0000***	-1.19769	0.1155	55.0595	0.8709
Yinchuan	-14.8574	0.0000****	-3.98867	0.0000****	93.0126	0.0237**
Zhengzhou	-3.84476	0.0001***	5.42423	1.0000	9.18487	1.0000

Notes:
(1) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.
(2) The lag length is fixed at 4.
(3) All tests with 'intercept and trend'.
(4) Shaded cities indicate convergence when they are used as the comparators.

Due to the advanced economic development of these powerful cities, their house price changes can signally affect the house prices of other cities. For example, as the capital of China, Beijing has the absolute superiority of economic development. While Shanghai, is one of four municipalities (Beijing, Shanghai, Tianjin and Chongqing) directly under the central government, and the core cities of YRD-EC as well. Moreover, Shenzhen is one of five municipalities with independent planning status, which have the strong industrial and commercial foundation and advanced science and technology. Furthermore, with the implementation of 'the West Development Strategy (*Xi Bu Da Kai Fa*)'[70], Urumchi and Yinchuan, as the capitals of Xinjiang province and Ningxia province respectively, are two of twelve major cities in this important strategy; since then Urumchi and Yinchuan have experienced a rapid developmental period. To this extent, that can explain why other cities' house prices remain an equilibrium relationship with these well-developed cities.

[70] In order to bridge the disparity between eastern coastal developed regions and western inland developing regions, the National People's Congress passed the West Development Strategy (*Xi Bu Da Kai Fa*) in 2001, that covering 12 provinces or municipalities—Chongqing, Shanxi, Gansu, Ningxia, Qinghai, Xinjiang, Sichuan, Yunnan, Guizhou, Tibet, Guangxi and Inner Mongolia.

4.5.2 Results of σ-/β-convergence

The coefficient of variation ($CV_t = \frac{S.D_t}{\overline{X}_t}$) for the regional house price index of 35 cities, follows the pattern as in Figure 4.9. As during the data revising process, the index has been set up at 100 in 1998Q1 for all the cities, the CV of zero in 1998Q1 has been dropped from the line graph. From inspection of this figure, it can be seen that CV exhibits a significant upward trend before 2004; afterwards it turns into a relative flat movement with slight fluctuation. The initial period is misleading. Obviously if we constrain all observations to equal 100 in the base quarter, then in succeeding quarters they will more upward, with the coefficient of variation increasing. This will continue until the equilibrium has been reached. The graph suggests this is by the end of 2004, after this date there is no compelling evidence for divergence or convergence.

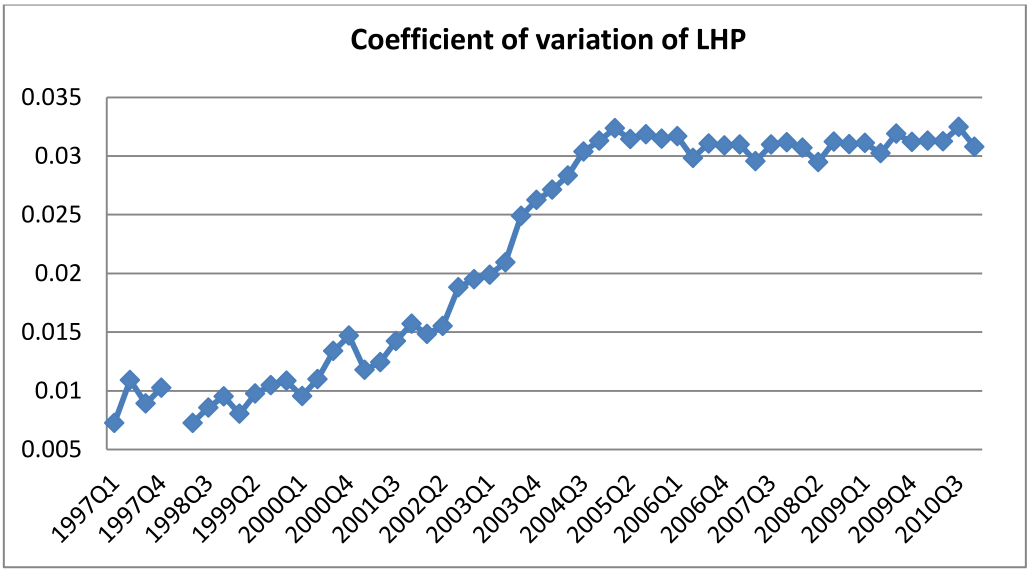


Figure 4.9: The Coefficient of Variation of LHP over 1997Q1-2010Q4

While, the σ-convergence shows how the distribution of house prices changes over time; in order to show the mobility of house prices with the same distribution, we apply the β-convergence as the complement of convergence analysis. As mentioned before, following Equation 4.18, we get the cross-section β-convergence model is $GLHP_i = \alpha + \beta LHP_{i,1} + \varepsilon$, where $GLHP_i$ is the growth rate for city i and $LHP_{i,1}$ is LHP for city i in the first time period. Additionally, the panel data version of β-convergence model is written as Equation 4.19, replace the link index HPI by LHP and get the following equation:

$GLHP_{i,\tau} = \alpha + \beta LHP_{i,\tau-1} + \varepsilon$, where $GLHP_{i,\tau}$ is the growth rate of LHP in the current time period and $LHP_{i,\tau-1}$ is LHP in the previous time period.

However, since the line graph for σ-convergence (Figure 4.9) does not reach an equilibrium until 2004, the sub-sample convergence consideration can be applied into our panel β-convergence estimation upon the example of Cook (2012). Hereby, the panel β-convergence regression is employed again with the cyclical sub-sample of observations from 2004Q1. Table 4.10 illustrates the results for both β-convergence models with full sample (1997Q1 to 2010Q4) and sub-sample (2004Q1 to 2010Q4).

Table 4.10: : Results of Both β-convergence Models with Full Sample and Sub-sample

Cross-section β-convergence model			**Panel β-convergence model (full sample)**			**Panel β-convergence model (sub-sample)**		
Dependent Variable	$GLHP_i$		Dependent Variable	$GLHP_{i,\tau}$		Dependent Variable	$GLHP_{i,\tau}$	
Number of obs	35		Number of obs	1925		Number of obs	980 (from 2004Q1)	
Explanatory Variable	Coefficient	p-value	Explanatory Variable	Coefficient	p-value	Explanatory Variable	Coefficient	p-value
$LHP_{i,1}$	-14.675 (-0.83)	0.415	$LHP_{i,1}$	-0.045 (-0.47)	0.635	$LHP_{i,\tau-1}$	-0.557 (-3.86)	0.000***
cons	78.350 (0.96)	0.343	cons	0.410 (0.90)	0.369	cons	3.012 (4.24)	0.000***

Note: ( ) denotes the t-statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

It can be seen from above table, for the full sample, the value of both coefficient β are negative; but the t-statistics are 0.415 and 0.635 respectively, which are not significant. Therefore, both results are not significant enough in support of β-convergence between regional house prices for the whole sample of observations. However, the regression of sub-samples exhibits the coefficient β (-0.557) is negative and significant at the 1% level, indicating apparent β-convergence for the sample level since the distribution reached an equilibrium.

In summary, the unit root techniques suggest that there is no evidence of China's regional house price indices converging to the national index. However, the panel version of β-convergence estimation detects the existence of convergence for sub-samples that is the convergence between regional house price indices during the period after 2003. The reason we use the period since 2004 is that before that the prices are being heavily influenced by the initial starting point with prices equal to 100 at the beginning of the period. In effect, what we are doing is seeing whether the differences in prices which have built up between 1997 and 2004 are subsequently corrected for. Therefore, regressions based on the period as a whole don't make much sense. Once the distribution had settled down, also in this period there is a strong evidence for either β-convergence or divergence.

4.5.3 Results of Cointegration Tests

As the results of unit root tests showed, the regional house price indexes are not stationary; thus, in order to test the long-run equilibrium relationship between regions, the next step is to estimate the cointegration of house price indexes. On one hand, Engle-Granger cointegration test is used for the bivariate varies between each two cities' house price indexes. On the other hand, Johansen cointegration test is used to investigate the long-run relationship between one specific city and core cities— Beijing, Shanghai, and Guangzhou.

Before the Engle-Granger cointegration test, seasonal dummy variables (S_1 denoting the 1st quarter, S_2 denoting the 2nd quarter and S_3 denoting the 3rd quarter) are introduced into the basic OLS models in the first step, and the results suggest that the seasonal dummies are significant. Thus, the seasonal dummies have been applied into Engle-Granger cointegration test. The lag length is specified by SIC. The null hypothesis is 'series are not cointegrated', in other words, rejecting the null means there is cointegration between series. Again, due to the significance of the time trend in Figure 4.7 and Table 4.5, the starting model used in the Engle-Granger cointegration tests is the 'linear trend'. Also, depending on the 'linear trend' model, Mackinnon (1996) critical values should be used.

Appendix 4.4 exhibits the pairwise Engle-Granger cointegration test results. It can be found that most of two cities do not have long-run equilibrium relationships, and the cointegration only exists between a few specific cities. Figure 4.10 highlights the cities which are linked by different colours. There is either one-way or two-way cointegration between these cities. As shown in the map, there is cointegration relationship between Hohhot, Taiyuan and Jinan, which are located around Beijing. The cointegration also exists between some coastal cities, such as Dalian, Fuzhou and Xiamen. In addition, more west inland cities illustrate cointegration relationship among Guiyang, Xi'an, Xining, Yinchuan and Urumqi; their linkage extends to a couple of Northeast cities, Changchun and Harbin.

Figure 4.10: The Map of Highlighted Cities with Cointegration Relationship

Table 4.11 summarises the statistical results of cointegration relationship between specific cities. It can be seen that there are bidirectional cointegration between Dalian and Fuzhou, Hohhot and Taiyuan at the 1% significance level; between Changchun and Guiyang, Changchun and Urumchi at the 5% significance level; between Nanchang and Qingdao, Shenzhen and Zhengzhou at the 10% significance level. And other two-way cointegration is between Hohhot and Jinan: Hohhot is cointegrated with Jinan at the 5% significance level; however Jinan is cointegrated with Hohhot at the 10% significance level. The other one-way cointegrations are significant only at the 10% significance level. In short, there are quite a few significant cointegration relationships between specific two cities without any trend or regular pattern. Thus, Granger causality test based on VAR model can be used to investigate the short-run relationship between cities in the next following part.

Table 4.11: The Pairwise Cointegration Relationship between Specific Cities

Direction of Cointegration	Engle-Granger Cointegration	Significant Level	Rationale
Two-way cointegration	Dalian long-run causality causes Fuzhou	1%	Both coastal cities.
	Fuzhou long-run causality causes Dalian	1%	
Two-way cointegration	Hohhot long-run causality causes Taiyuan	1%	Both inland cities roughly equal distance from Beijing.
	Taiyuan long-run causality	1%	

	causes Hohhot		
Two-way cointegration	Changchun long-run causality causes Guiyang	5%	Both interior cities relatively remote.
	Guiyang long-run causality causes Changchun	5%	
Two-way cointegration	Changchun long-run causality causes Urumchi	5%	Urumchi or Urumqi (on map) both interiror and remote.
	Urumchi long-run causality causes Changchun	5%	
Two-way cointegration	Hohhot long-run causality causes Jinan	5%	Both interior cities roughly equal distance from Beijing.
	Jinan long-run causality causes Hohhot	10%	
Two-way cointegration	Nanchang long-run causality causes Qingdao	10%	No obvious shared charateristics.
	Qingdao long-run causality causes Nanchang	10%	
Two-way cointegration	Shenzhen long-run causality causes Zhengzhou	10%	No obvious shared charateristics.
	Zhengzhou long-run causality causes Shenzhen	10%	
One-way cointegration	Fuzhou long-run causality causes Xiamen	10%	Both coastal cities in Fujian Province; Fuzhou is the capital city of Fujian.
One-way cointegration	Harbin long-run causality causes Guiyang	10%	No obvious shared charateristics.
One-way cointegration	Xi'an long-run causality causes Xining	10%	Both interior cities relatively remote.
One-way cointegration	Xining long-run causality causes Changchun	10%	Both interior cities relatively remote.
One-way cointegration	Xining long-run causality causes Yinchuan	10%	Both inland cities are remote and close to each other.

Notes:
(1) The lag length is specified by SIC.
(2) The seasonal dummies 'S_1, S_2 and S_3' have been applied into the Engle-Granger cointegration tests.
(3) The null hypothesis is 'series are not cointegrated'.
(4) The trend specification is 'linear trend'.
(5) Mackinnon (1996) p-values.
(6) '1%', '5%' or '10%' means to reject H_0 at 1%, 5% and 10% level respectively.
(7) 'Two-way cointegration' means two cities are cointegrated with each other; while 'one-way cointegration' means one city is cointegrated with the other one, but not vice versa.[71]

Then, we can choose the most important cities in three economic zones—Beijing, Shanghai and Guangzhou—to run Johansen system cointegration test. The hypothesis is 'there are at most *n* cointegration equations'. For example, if we fail to reject the null of 'None' means there is no cointegration at the 5% level; and if we fail to reject the null of 'At most 1' means there is 1 cointegration equation among multivariate series at the 5% level. As mentioned before, the seasonal dummies are significant and applied into Johansen cointegration test as

[71] More specifically, I have run two regressions, with each variable as the dependent variable, and then causality goes from the explanatory to the dependent variable. This is because according to Granger representation theorem, if there is cointegration it implies there is a valid error correction model, as the error correction term must then be significant it means there is long-run causality from the explanatory to the dependent variable. However, the E-G test for cointegration is different to a causality test, although one implies the other through the Granger representation theorem. (Granger *et al.*, 2000)

well. However, the critical values for Johansen cointegration test from MacKinnon-Haug-Michelis (1999) assume no exogenous series. Meanwhile, since we have four series for each system for the cointegration test and only have 56 time periods (1997Q1 to 2010Q4), too many lags will cause too many instruments and reduce the degrees of freedom of the test; thus, the lag interval is fixed at 1 to 2.

As Figure 4.7 and Table 4.5 displayed, generally there is an upward trend of regional house prices over the decade; necessarily, the significance of the trend needs to be tested in order to compare the results of Johansen cointegration tests without the trend and with the trend. **Error! Reference source not found.** illustrates the significance test for regional house price indices; and there is strong evidence of all the cities having a significant trend at the 1% level. Consequently, the test with the trend is more appropriate than the test without the trend to this extent. Table 4.12 states the results of Johansen cointegration test with trend and without trend. According to the table, the results without the trend suggest most of the 32 cities are cointegrated with the core cites—Beijing, Shanghai and Guangzhou, except for Fuzhou, Hohhot, Jinan, Nanchang, Shijiazhuang, Taiyuan, Wuhan and Xiamen; while the results with the trend suggest most cities area cointegrated with the core cities except for Harbin and Wuhan. As a general view of both tests, only Wuhan has no cointegration relationship with the core cities, which means there is a long run equilibrium relationship of house prices between most cities with the core cities. Therefore, the primary results of Johansen cointegration test supports our assumption of house prices in core cites having effects on other cities; hence, the panel regression models based on core cities are applied in the next step.

Table 4.12: Johansen System Cointegration Test with Trend and Without Trend

Cointegration between Specific City and Core Cities—Beijing, Shanghai and Guangzhou							
City code	**City**	**Unrestricted Cointegration Rank Test (without trend)**			**Unrestricted Cointegration Rank Test (with trend)**		
		Hypothesized No. of CE(s)	**Trace Statistic**	**Prob. ****	**Hypothesized No. of CE(s)**	**Trace Statistic**	**Prob. ****
2	Changchun	None*	58.90005	0.0033	None*	74.36717	0.0051
		At most 1	25.61340	0.1407	At most 1	40.87171	0.0789
3	Changsha	None*	49.80504	0.0324	None*	65.52791	0.0361
		At most 1	22.50229	0.2714	At most 1	35.67966	0.2182
4	Chengdu	None*	58.29007	0.0039	None*	78.41005	0.0019
		At most 1*	30.81345	0.0381	At most 1*	43.14009	0.0475
		At most 2	12.17790	0.1486	At most 2	24.20348	0.0795
5	Chongqing	None*	59.80306	0.0026	None*	77.52336	0.0023

		At most 1	28.18070	0.0759	At most 1*	45.89864	0.0244
		-	-	-	At most 2	17.35555	0.3889
6	Dalian	None*	57.61763	0.0047	None*	80.51302	0.0011
		At most 1	28.47877	0.0704	At most 1*	47.21820	0.0175
		-	-	-	At most 2	23.92520	0.0857
7	Fuzhou	None	37.33932	0.3317	None*	64.82067	0.0416
		-	-	-	At most 1	30.96046	0.4462
9	Guiyang	None*	98.05702	0.0000	None*	106.5473	0.0000
		At most 1*	42.98064	0.0009	At most 1*	51.37191	0.0058
		At most 2	10.76964	0.2261	At most 2	16.88051	0.4239
10	Haikou	None*	50.21040	0.0295	None*	75.89816	0.0035
		At most 1	25.15976	0.1558	At most 1	37.54103	0.1555
11	Hangzhou	None*	59.62898	0.0027	None*	84.78710	0.0003
		At most 1	28.65690	0.0672	At most 1*	53.46092	0.0032
		-	-	-	At most 2*	26.30457	0.0442
		-	-	-	At most 3	8.877495	0.1880
12	Harbin	None*	50.50816	0.0276	None	62.55810	0.0642
		At most 1	27.08429	0.0996	-	-	-
13	Hefei	None*	54.23344	0.0112	None*	66.06710	0.0323
		At most 1	26.13153	0.1248	At most 1	33.83572	0.2961
14	Hohhot	None	44.73019	0.0955	None*	88.43577	0.0001
		-	-	-	At most 1	42.03264	0.0611
15	Jinan	None	47.00286	0.0600	None*	75.93379	0.0035
		-	-	-	At most 1	42.41320	0.0561
16	Kunming	None*	57.98307	0.0042	None*	85.96066	0.0002
		At most 1	19.01378	0.4919	At most 1	38.54337	0.1279
17	Lanzhou	None*	52.53835	0.0170	None*	68.78649	0.0182
		At most 1	20.88872	0.3646	At most 1	33.47070	0.3133
18	Nanchang	None	42.11999	0.1554	None*	79.33746	0.0015
		-	-	-	At most 1	40.88809	0.0787
19	Nanjing	None*	67.25250	0.0003	None*	83.95765	0.0004
		At most 1	22.41248	0.2761	At most 1	39.03650	0.1159
20	Nanning	None*	53.72163	0.0127	None*	69.24690	0.0165
		At most 1*	31.00858	0.0361	At most 1*	43.46488	0.0440
		At most 2	12.83358	0.1211	At most 2	20.77698	0.1891
21	Ningbo	None*	62.66966	0.0011	None*	89.63761	0.0001
		At most 1	25.28947	0.1513	At most 1	42.75370	0.0519
22	Qingdao	None*	51.31096	0.0228	None*	93.99455	0.0000
		At most 1	21.57660	0.3226	At most 1	41.73242	0.0654
24	Shenyang	None*	49.01355	0.0388	None*	78.27096	0.0019
		At most 1	23.37997	0.2279	At most 1	36.14773	0.2009
25	Shenzhen	None*	64.13964	0.0007	None*	103.0161	0.0000
		At most 1	26.59983	0.1118	At most 1*	53.45467	0.0032
		-	-	-	At most 2	22.33071	0.1297
26	Shijiazhuang	None	45.05481	0.0895	None*	67.83422	0.0224
		-	-	-	At most 1	39.24833	0.1110
27	Taiyuan	None	42.09701	0.1560	None*	67.14942	0.0259
		-	-	-	At most 1	37.51951	0.1561

28	Tianjin	None*	54.29697	0.0110	None*	70.50989	0.0125
		At most 1*	33.40388	0.0184	At most 1*	49.37258	0.0100
		At most 2	15.19190	0.0555	At most 2*	29.48993	0.0169
		-	-	-	At most 3*	12.82161	0.0445
29	Urumchi	None*	53.98219	0.0119	None*	96.06180	0.0000
		At most 1	25.18902	0.1548	At most 1*	47.00979	0.0185
		-	-	-	At most 2	21.40736	0.1628
30	Wuhan	None	39.77416	0.2307	None	62.43863	0.0657
31	Xi'an	None*	72.08303	0.0001	None*	95.49763	0.0000
		At most 1*	31.01317	0.0361	At most 1*	43.48027	0.0438
		At most 2	9.589703	0.3136	At most 2	18.37217	0.3195
32	Xiamen	None	41.65254	0.1687	None*	72.44612	0.0080
		-	-	-	At most 1	34.14298	0.2820
33	Xining	None*	59.99855	0.0024	None*	82.67064	0.0006
		At most 1*	31.17489	0.0345	At most 1*	44.51556	0.0343
		At most 2	15.21060	0.0551	At most 2	22.16436	0.1352
34	Yinchuan	None*	66.96116	0.0003	None*	78.92184	0.0016
		At most 1	29.16793	0.0590	At most 1	35.95126	0.2080
35	Zhengzhou	None*	50.30812	0.0289	None*	71.39502	0.0102
		At most 1	28.77638	0.0652	At most 1	39.13441	0.1136

Notes:
1) The null hypothesis is 'there are at most number of *n* cointegration equations'.
2) Exogenous series: seasonal dummy variables (s1 s2 s3).
3) Lags interval (in first difference): 1 to 2.
4) * denotes rejection of the hypothesis at the 5% level.
5) **MacKinnon-Haug-Michelis (1999) p-values.
6) Warning: Critical values assume no exogenous series.

4.5.4 Results of Panel Regression Models

As multivariate cointegration tests showed, house prices in most cities are cointegrated with house prices in core cities—Beijing, Shanghai and Guangzhou, recalling Equation 4.25 and 4.26, we use the stationary variable of DLHP to replace the index and then achieve the following models:

$$DLHP_{i,\tau} = \alpha + \delta_1 DLHP_{B,\tau-1} + \delta_2 DLHP_{S,\tau-1} + \delta_3 DLHP_{G,\tau-1} + \beta DLHP_{i,\tau-1} + \varepsilon_{i,\tau} \tag{4.36}$$

$$\begin{aligned} DLHP_{i,\tau} &= \alpha + \delta_1 DLHP_{B,\tau-1} + \delta_2 DLHP_{S,\tau-1} + \delta_3 DLHP_{G,\tau-1} \\ &\eta_1 dDLHP_{B,\tau-1} + \eta_2 dDLHP_{S,\tau-1} + \eta_3 dDLHP_{G,\tau-1} + \beta DLHP_{i,\tau-1} + \varepsilon_{i,\tau} \end{aligned} \tag{4.37}$$

The above equations indicate the ripple effects of quarterly house price changes in Beijing, Shanghai and Guangzhou; in order to identify the impact of yearly house prices swings in these cities, the variable of the 4th difference of LHP (D4LHP) is introduced to replace the 1st difference variable (DLHP). The advantage of using the annual change is that it is actual data. The quarterly data is estimated and may contain error terms as we reconstruct the constant growth index from the link index. But the annual data has a problem too. Clearly the annual change for this quarter is very similar to last quarter. To overcome this we regress the annual change not on last quarter's annual change but the annual change four quarters previously. In this case, the annual house price change regressions can be expressed as:

$$\begin{aligned} &D4LHP_{i,\tau} = \alpha + \delta_1 D4LHP_{B,\tau-4} + \delta_2 D4LHP_{S,\tau-4} \\ &+ \delta_3 D4LHP_{G,\tau-4} + \beta D4LHP_{i,\tau-4} + \varepsilon_{i,\tau} \end{aligned} \tag{4.38}$$

$$\begin{aligned} &D4LHP_{i,\tau} = \alpha + \delta_1 D4LHP_{B,\tau-4} + \delta_2 D4LHP_{S,\tau-4} + \delta_3 D4LHP_{G,\tau-4} \\ &\eta_1 dD4LHP_{B,\tau-4} + \eta_2 dD4LHP_{S,\tau-4} + \eta_3 dD4LHP_{G,\tau-4} + \beta D4LHP_{i,\tau-4} + \varepsilon_{i,\tau} \end{aligned} \tag{4.39}$$

Where τ denotes the time period from 1997Q1 to 2010Q4; $i=1,2,\ldots,32$, which denotes 32 cities excluding Beijing, Shanghai and Guangzhou. $DLHP_B$, $DLHP_S$ and $DLHP_G$ are quarterly house price changes of core cities—Beijing, Shanghai and Guangzhou respectively. $dDLHP_B$ is the log of distance between city i and Beijing multiplying DLHP in Beijing; $dDLHP_S$ is the log of distance between city i and Shanghai multiplying DLHP in Shanghai; and $dDLHP_G$ is the log of distance between city i and Guangzhou multiplying DLHP in Guangzhou. $D4LHP_B$, $D4LHP_S$ and $D4LHP_G$ are yearly house price changes in Beijing, Shanghai and Guangzhou respectively. $dD4LHP_B$ is the log of distance between city i and Beijing multiplying $D4LHP$ in Beijing; $dD4LHP_S$ is the log of distance between city i and Shanghai multiplying $D4LHP$ in Shanghai; and $dD4LHP_G$ is the log of distance between city i and Guangzhou multiplying $D4LHP$ in Guangzhou. Table 4.13 and Table 4.14 exhibit the results of the panel regression models for quarterly and yearly house price changes respectively.

From Table 4.13 and Table 4.14, it can be seen that both quarterly and yearly house price changes in other cities are significantly affected by their own lagged changes and house price changes in Beijing and Shanghai, no matter including the distance factor or not. In another words, the house price shocks in core cities ‘ripple out’ to the other regions; because the development situations in these three biggest economic zones stimulate the economic growth of comparatively low developed regions, which is the major aim of China’s central government to build up economic zones.

Table 4.13: Results of Ripple Effect Regressions for Beijing, Shanghai and Guangzhou (the first difference for quarterly change)

Dependent Variable	Quarterly house price changes (DLHP) in city *i*				
Explanatory Variable	Coefficient	p-value	**Explanatory Variable**	Coefficient	p-value
L.DLHP	-0.261 (-11.33)	0.000***	*L.DLHP*	-0.201 (-2.28)	0.023**
$L.DLHP_B$	0.410 (7.96)	0.000***	$L.DLHP_B$	0.414(8.04)	0.000***
			$L.dDLHP_B$	-0.010(-0.81)	0.419
$L.DLHP_S$	0.058 (2.15)	0.031**	$L.DLHP_S$	0.604(2.37)	0.018**
			$L.dDLHP_S$	-0.075(-2.15)	0.032**
$L.DLHP_G$	0.095 (3.23)	0.001***	$L.DLHP_G$	0.778(2.61)	0.009***
			$L.dDLHP_G$	-0.092(-2.30)	0.021**
cons	0.007 (6.33)	0.000***	cons	0.007 (6.38)	0.000***

Notes:
1). ‘L.’ indicates the first lag of variables. ‘D’ indicates the first difference.
2). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
3). These correspond to equations 5.36 and 5.37.

Table 4.14: Results of Ripple Effect Regressions for Beijing, Shanghai and Guangzhou (the fourth difference for yearly change)

Dependent Variable	Yearly house price changes (D4LHP) in city *i*				
Explanatory Variable	Coefficient	p-value	**Explanatory Variable**	Coefficient	p-value
L4.D4LHP	0.192 (6.01)	0.000***	*L4.D4LHP*	0.152 (4.46)	0.000***
$L4.D4LHP_B$	-0.346 (-8.55)	0.000***	$L4.D4LHP_B$	-0.520(-2.66)	0.008***
			$L4.dD4LHP_B$	0.027(1.00)	0.318
$L4.D4LHP_S$	0.039 (2.71)	0.007***	$L4.D4LHP_S$	0.681(5.18)	0.000***
			$L4.dD4LHP_S$	-0.088(-4.93)	0.000***
$L4.D4LHP_G$	0.420 (9.86)	0.000***	$L4.D4LHP_G$	-0.148(-0.47)	0.637
			$L4.dD4LHP_G$	0.077 (1.83)	0.068*
cons	0.041 (23.59)	0.000***	cons	0.041 (23.99)	0.000***

Notes:
1). ‘L4.’ indicates lag 4 of variables. ‘D4’ indicates the fourth difference.
2). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
3). These correspond to equations 5.38 and 5.39.

Additionally, the positive coefficients of core cities’ quarterly house price changes indicate that house prices in core cities play a motivational role in other regions. More interestingly, the coefficients of previous house price changes are significantly negative in the short run (in terms of quarter) and significantly positive in the long run (in terms of year). This means previous house price shocks have a negative influence on the current house prices in the short run, but the house price turbulences have a positive impact on the current house prices in the long run. Specifically, if the house price increases in the short-run current quarter, it will drop in the next quarter; but if it rises in the long-run current year, it will increase in the next year as well. The quarterly change may be more influenced by random stochastic factors than the annual figure, which will be dominated perhaps more by the underlying trend. This suggests that the stochastic factors are corrected for, whilst the long term factors have a continuing impact.

Another interesting result is the different ripple effect of Beijing's house price shocks in the short run and in the long run. As we can see that, the increase of quarterly house price changes in Beijing drive up other cities' house price, but the growth of yearly house price changes in Beijing decreases other cities' house prices. Although when we bring in the distance factors, the coefficient of Beijing stops being significant. One interpretation of these results is that the impact of a house price change in Beijing is felt quickly in other cities, as reflected by the coefficient in Table 4.13 (0.410) in comparison with the other core cities coefficients, this not diluted by distance. Thus when we consider a year lagged effects are reflected in cities by their own prices and Beijing prices perform the role of a correction factor. This may be because in the long-run, Beijing acts as a magnet for migration, as extra people move to the capital and they push prices up. But this then may lead to downward pressure on other cities. That is one possibility, and there are of course others.

Furthermore, for the quarterly house price swings, the ripple effects seem to be impacted by the distance factor in Shanghai and Guangzhou but not in Beijing, because the coefficients of distance factors are significant at the 5% level in Shanghai and Guangzhou but not significant in Beijing. However, for the yearly house price fluctuations, only the distance factor of Shanghai is significant at the 1% level. Also the coefficients of distance factors (*L.dDLHP* and *L4.dD4LHP*) in Table 4.13 and Table 4.14 are negative, where the negativity of coefficients of price factors implies that the farther the city is away from economic zones, the less powerful the distance factor is. This evidence suggests that the 'ripple effects' of house price turbulence in core cities weakens with the increase of the distance and in the long run (in terms of year). We should expect the distance factor to decline with the length of the time period. It takes time for price effects to spread across the country and the farther the distance, the longer it takes. But after a year much of the impact has been felt regardless of distance.

4.5.5 Results of Granger Causality Tests

As the supplement of cointegration tests, the alternative method of Granger Causality Test can be adopted into regional house price estimation. Since the unit root tests demonstrate all the series are non-stationary and Engle-Granger pairwise cointegration tests illustrate there is no cointegration relationship between most of two cites. Thus, we can run Granger causality test for the difference format of house price indexes in the following step. Appendix 4.5 and Appendix 4.6 show the results of 'Pairwise Granger Causality Tests' for 1^{st} difference and 4^{th} difference of LHP respectively and also highlight the most powerful cities in impacting on other cities' house prices. We fixed the lag length for the Granger Causality tests at 2, as we have limited data with only 56 time periods. The null of Granger causality test is 'A does not cause B', so reject the null means house price changes in city A causes house price changes in city B.

Once more we reproduce the map and highlight the key cities (Figure 4.11). Granger causality test, for the 1^{st} difference of LHP, investigates whether the quarterly house price changes in one city affects the other cities'. Whilst the test with 4^{th} the difference of LHP estimates whether the yearly price shocks in one city affects the other cities. Table 4.15 summarise the results of pairwise Granger causality tests from Appendix 4.5 and Appendix 4.6. It shows that the quarterly changes of house prices (the lagged variables lagged 1 period) in Beijing, Hangzhou and Shenzhen affect house prices of most other cities, and the yearly changes (the lagged variables lagged 4 periods) in most other cities are impacted upon by the house price shocks in Beijing, Guangzhou, Hangzhou and Shenzhen. These four influential core cities are highlighted by purple ellipses in the map of Figure 4.11.

Figure 4.11: The Map of Highlighted Cities by Granger Causality Test

Table 4.15: Number of Cities of Each City Causes Other Cities

Granger Causality Test for 1^{st} Difference of LHP						**Granger Causality Test for 4^{th} Difference of LHP**					
City Code	**Cities**	**reject the null**			**fail to reject the null**	**City Code**	**Cities**	**reject the null**			**fail to reject the null**
		1% ***	**5% ****	**10% ***	**×**			**1% *****	**5% ****	**10% ***	**×**
1	Beijing	19	7	2	6	**1**	Beijing	15	8	5	6
2	Changchun	13	8	2	11	**2**	Changchun	1	2	2	29
3	Changsha	12	9	2	11	**3**	Changsha	5	8	5	16
4	Chengdu	11	7	4	12	**4**	Chengdu	0	7	2	25
5	Chongqing	10	4	3	17	**5**	Chongqing	5	6	6	17
6	Dalian	9	8	3	14	**6**	Dalian	4	7	1	22
7	Fuzhou	8	4	4	18	**7**	Fuzhou	0	5	2	27
8	Guangzhou	8	4	4	18	**8**	Guangzhou	12	8	5	9
9	Guiyang	4	6	4	20	**9**	Guiyang	1	5	6	22
10	Haikou	6	2	2	24	**10**	Haikou	1	3	4	26
11	Hangzhou	16	3	5	10	**11**	Hangzhou	6	14	3	11
12	Harbin	12	6	3	13	**12**	Harbin	3	5	5	21
13	Hefei	12	3	2	17	**13**	Hefei	3	4	2	25
14	Hohhot	13	6	4	11	**14**	Hohhot	0	2	3	29
15	Jinan	15	2	3	14	**15**	Jinan	6	2	1	25
16	Kunming	12	5	0	17	**16**	Kunming	3	7	4	20
17	Lanzhou	12	1	2	19	**17**	Lanzhou	4	1	2	27
18	Nanchang	2	7	4	21	**18**	Nanchang	2	5	1	26
19	Nanjing	7	6	3	18	**19**	Nanjing	10	8	4	12

20	Nanning	4	3	2	25	**20**	Nanning	3	4	1	26
21	Ningbo	7	5	3	19	**21**	Ningbo	1	9	4	20
22	Qingdao	8	4	4	18	**22**	Qingdao	3	4	4	23
23	Shanghai	6	2	5	21	**23**	Shanghai	3	3	6	22
24	Shenyang	16	1	1	16	**24**	Shenyang	2	5	8	19
25	Shenzhen	16	7	3	8	**25**	Shenzhen	22	7	1	4
26	Shijiazhuang	6	6	1	21	**26**	Shijiazhuang	4	8	8	14
27	Taiyuan	12	1	2	19	**27**	Taiyuan	0	2	1	31
28	Tianjin	11	3	3	17	**28**	Tianjin	5	7	6	16
29	Urumchi	4	4	7	19	**29**	Urumchi	5	10	3	16
30	Wuhan	13	2	0	19	**30**	Wuhan	2	1	1	30
31	Xi'an	12	10	1	11	**31**	Xi'an	4	10	4	16
32	Xiamen	9	8	3	14	**32**	Xiamen	5	6	6	17
33	Xining	9	5	2	18	**33**	Xining	0	3	1	30
34	Yinchuan	9	6	0	19	**34**	Yinchuan	2	6	6	20
35	Zhengzhou	7	10	4	13	**35**	Zhengzhou	1	1	2	30

Notes:
1) Pairwise Granger Causality Tests take 2 lags.
2) The null hypothesis is 'the city X does not cause the city Y'.
3) ***, **, and * indicate significance at 1%, 5%, and 10% level respectively, which means ***, ** and * reject the null hypothesis at 1%, 5%, and 10% level respectively.

As mentioned above, Beijing is the core city of Beijing-Tianjin-Tangshan economic zone, Hangzhou is another core city of Yangtze River Delta economic zone except for Shanghai, Guangzhou and Shenzhen are the core cities of Pearl River Delta economic zone; therefore, the pairwise Granger causality results coincide with our regression estimation in Table 4.13 and Table 4.14, to some extent. But not as expected, Shanghai's house prices affect just few other cities' house price changes. This may reflect the degree of difference between Shanghai, the commercial hub of China and probably the most westernized city, and other major cities. In addition, house prices in Guangzhou do not impact other cities' in a manner of quarterly changes; but in the long run, Guangzhou has much wider influence on other cities by yearly turbulences.

Based on the above results, for the quarterly house price changes, if we assume Hangzhou and Shenzhen play a core role rather than Shanghai and Guangzhou in Yangtze and Pearl River Delta economic zones respectively, Equation 4.36 & 4.37 can be rewritten as:

$$DLHP_{i,\tau} = \alpha + \delta_1 DLHP_{B,\tau-1} + \delta_2 DLHP_{HZ,\tau-1} + \delta_3 DLHP_{SZ,\tau-1} + \beta DLHP_{i,\tau-1} + \varepsilon_{i,\tau} \tag{4.40}$$

$$\begin{aligned} DLHP_{i,\tau} &= \alpha + \delta_1 DLHP_{B,\tau-1} + \delta_2 DLHP_{HZ,\tau-1} + \delta_3 DLHP_{SZ,\tau-1} \\ &\eta_1 dDLHP_{B,\tau-1} + \eta_2 dDLHP_{HZ,\tau-1} + \eta_3 dDLHP_{SZ,\tau-1} + \beta DLHP_{i,\tau-1} + \varepsilon_{i,\tau} \end{aligned} \tag{4.41}$$

In addition, the above results suggest that for the yearly house price changes, one more city—Guangzhou—has an important impact, therefore Equation 4.38 & 4.39 can be rewritten as:

$$\begin{aligned} D4LHP_{i,\tau} &= \alpha + \delta_1 D4LHP_{B,\tau-4} + \delta_2 D4LHP_{HZ,\tau-4} \\ &+ \delta_3 D4LHP_{SZ,\tau-4} + \delta_4 D4LHP_{G,\tau-4} + \beta D4LHP_{i,\tau-4} + \varepsilon_{i,\tau} \end{aligned} \tag{4.42}$$

$$\begin{aligned} D4LHP_{i,\tau} &= \alpha + \delta_1 D4LHP_{B,\tau-4} + \delta_2 D4LHP_{HZ,\tau-4} + \delta_3 D4LHP_{SZ,\tau-4} \\ &+ \delta_4 D4LHP_{G,\tau-4} + \eta_1 dD4LHP_{B,\tau-4} + \eta_2 dD4LHP_{HZ,\tau-4} \\ &+ \eta_3 dD4LHP_{SZ,\tau-4} + \eta_4 dD4LHP_{G,\tau-4} + \beta D4LHP_{i,\tau-4} + \varepsilon_{i,\tau} \end{aligned} \tag{4.43}$$

where τ denotes the time period from 1997Q1 to 2010Q4; $i=1,2,\ldots,32$, which denotes 32 cities excluding Beijing, Hangzhou and Shenzhen. Other new variables $DLHP_{HZ}$/ $D4LHP_{HZ}$, $DLHP_{SZ}/D4LHP_{SZ}$, and $DLHP_{G}/D4LHP_{G}$ are quarterly/yearly house price changes of Hangzhou, Shenzhen and Guangzhou respectively; $dDLHP_{HZ}/dD4LHP_{HZ}$ are the log of distance between city i and Hangzhou multiplying *DLHP/D4LHP* in Hangzhou; $dDLHP_{SZ}/dD4LHP_{SZ}$ are the log of distance between city i and Shenzhen multiplying *DLHP/D4LHP* in Shenzhen; and $dDLHP_{G}/dD4LHP_{G}$ are the log of distance between city i and Guangzhou multiplying *DLHP/D4LHP* in Guangzhou. Table 4.16 and Table 4.17 illustrate the results of the panel regression models for quarterly and yearly house price changes respectively.

As the Granger Causality results suggest, the quarterly house price changes of Beijing, Hangzhou and Shenzhen affect most other cities' house prices, and the yearly house price changes of Beijing, Hangzhou, Guangzhou and Shenzhen impact most other cities' house prices. The same conclusions with Table 4.13 and Table 4.14, the coefficients of previous house price changes in Table 4.16 and Table 4.17 are significantly negative in the short run (in terms of quarter) and significantly positive in the long run (in terms of year).

Table 4.16: Results of Ripple Effect Regressions for Beijing, Hangzhou and Shenzhen (the first difference for quarterly change)

Dependent Variable	Quarterly house price changes (DLHP) in city i				
Explanatory Variable	Coefficient	p-value	**Explanatory Variable**	Coefficient	p-value
L.DLHP	-0.230 (-9.96)	0.000***	*L.DLHP*	-0.183 (-2.06)	0.040**
$L.DLHP_B$	0.232 (3.58)	0.000***	$L.DLHP_B$	0.232(3.59)	0.000***
			$L.dDLHP_B$	-0.006(-0.51)	0.607

$L.DLHP_{HZ}$	-0.008 (-0.28)	0.778	$L.DLHP_{HZ}$	0.129(0.59)	0.558
			$L.dDLHP_{HZ}$	-0.019(-0.63)	0.531
$L.DLHP_{SZ}$	0.119 (3.05)	0.002***	$L.DLHP_{SZ}$	0.966(2.88)	0.004***
			$L.dDLHP_{SZ}$	-0.113(-2.54)	0.011**
cons	0.008 (7.51)	0.000***	cons	0.008 (7.50)	0.000***

Notes:
1). 'L.' indicates the first lag of variables, 'D' indicates the first difference.
2). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
3). These correspond to equations 5.40 and 5.41.

Table 4.17: Results of Ripple Effect Regressions for Beijing, Hangzhou, Shenzhen and Guangzhou (the fourth difference for yearly change)

Dependent Variable	Yearly house price changes (D4LHP) in city *i*				
Explanatory Variable	Coefficient	p-value	**Explanatory Variable**	Coefficient	p-value
$L4.D4LHP$	0.407 (13.40)	0.000***	$L4.D4LHP$	0.389 (12.38)	0.000***
$L4.D4LHP_B$	-0.359 (-9.17)	0.000***	$L4.D4LHP_B$	-0.626(-3.28)	0.001***
			$L4.dD4LHP_B$	0.038(1.45)	0.146
$L4.D4LHP_{HZ}$	-0.315 (-9.49)	0.000***	$L4.D4LHP_{HZ}$	0.127(0.79)	0.429
			$L4.dD4LHP_{HZ}$	-0.061(-2.82)	0.005***
$L4.D4LHP_{SZ}$	0.006 (0.24)	0.811	$L4.D4LHP_{SZ}$	-0.746(-2.09)	0.036**
			$L4.dD4LHP_{SZ}$	0.099(2.12)	0.034**
$L4.D4LHP_G$	0.476 (8.96)	0.000***	$L4.D4LHP_G$	0.736(1.11)	0.269
			$L4.dD4LHP_G$	-0.034(-0.39)	0.697
cons	0.053 (25.31)	0.000***	cons	0.053 (25.44)	0.000***

Notes:
1). 'L4.' indicates lag 4 of variables, 'D4' indicates the fourth difference.
2). ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.
3). These correspond to equations 5.42 and 5.43.

From Table 4.16, the implications of regression models are slightly different with our assumption based on the Granger Causality tests: the quarterly house price shocks in Beijing and Shenzhen significantly disturb other cities' housing market regardless of distance factors at the 1% level; but Hangzhou's quarterly house price changes do not have a significant effect on other cities' in both situations, excluding and including distance factor. Meanwhile, from Table 4.17, the yearly house price shocks are significant in Beijing, Hangzhou and Guangzhou without the distance factors; but with the distance factors, the yearly house price fluctuations are only significant in Beijing and Shenzhen at 1% and 5% significance level respectively. In the long run, Shenzhen's yearly house price changes cannot significantly affect other cities; but including the distance factor, its coefficient is significant as well as the coefficient of Shenzhen's distance factor.

Speaking to the distance factor, in the quarterly house price change regression, the coefficient of Beijing is not significant either. However, the distance factor of Shenzhen plays a significant role in other cities' house prices at the 5% level. According to the policies of reform and opening-up, Shenzhen has become the first window of China's reform and opening up in the south of China, and also one of the first special economic cities. The advanced economic status contributes to its leading economic role in China, which is the most important reason of Shenzhen's profound influence on other cities' housing markets. In the long run yearly term, the distance factors of Beijing and Guangzhou are not significant, which means the distance factor cannot affect the house price swings in the long run equilibrium. By cross comparing with Table 4.14 and Table 4.17, the original results in Table 4.14 are overall better than these results in Table 4.17 which indicating the original intuition on choice of cities (Beijing, Shanghai and Guangzhou) was more efficient and valid.

In a sense these tables (Table 4.13, Table 4.14, Table 4.16 and Table 4.17) generalise the Granger causality tests which just focus on a relationship between TWO variables. This reflects the possibility that city house prices may be impacted upon by more than one 'core city'.

4.6 Conclusion

This chapter analyses the house price indexes for 35 cities over 1998Q1 to 2010Q4, to study the convergence and ripple effects of China's regional house prices, through univariate/panel unit root tests (Levin *et al.*, Im *et al.*, ADF, PP, and Hadri tests), σ-/β-convergence analysis, panel regression models, cointegration tests and Granger causality test. Overall, the results indicate non-convergence between China's regional house prices during this period. However, there is evidence of ripple effects of some core cities in three major economic zones—BTT-EC, YRD-EC and PRD-EC, especially in the short run (in terms of quarterly). The fact that we have ripple effects but not convergence may indicate that the influence from one city to another exists, but is not in itself enough to ensure convergence. On the other hand we may simply need more data, more time periods.

Before running the econometric tests and regressions, the original link index for house prices (index in the same quarter of last year=100) is revised into a continual index (index in the first quarter=100) by making an assumption of 'annual growth rate = (quarterly growth rate)^4' in periods of high stability. The results are reasonable and suggest our assumption is valid and the transferred index can estimate the house price changes efficiently. Afterwards, the new index has been used in the following estimations.

Firstly, we test the stationarity of the regional-national house price ratio for each city by ADF, DF-GLS and KPSS unit root tests, and there is no evidence of convergence between these cities. Furthermore, the panel unit root tests—LLC, IPS, ADF, PP and Hadri tests—reemphasize the non-convergence of China' regional house price indexes to national index. We further identify different 'clubs' by using each city as benchmark city to get house price index ratios, for example, a 'club' of house price index ratios can be obtained via using each other city's house price index dividing Beijing's house price index. Within 'clubs', panel unit root tests indicate there is evidence of limited convergence to Beijing, Shanghai, Shenyang, Shenzhen, Urumchi and Yinchuan.

Then, both the σ-convergence test and the β-convergence test demonstrate the non-convergence of regional house prices as well. This is the period from when the distribution of house prices 'settled down' after being 'forced' to coincide initially with all having a value of 100. The σ-convergence from this period onwards showed no signs of either convergence or divergence. However, for the sub-sample of variation starting from 2004Q1, the panel regression suggests there is a strong evidence of the β-convergence between regional house prices. These of course are not necessarily inconsistent as the two definitions of convergence to an extent reflect different aspects of convergence.

The inequality in China recently explains the non-convergence in China's regional house prices, to a great extent. As introduced in the background chapter (Chapter 2), the housing inequity for householders with different income is one of the major problems in Chinese housing market. Sicular (2011) uses 'the China Household Income Project (CHIP)' survey data to reveal the wider gap. The data of disposable net income per capita come from the 1988, 1995, 2002 and 2007 CHIP survey respectively, and the income inequity is measured by Gini coefficient[72]. Figure 4.12 indicates the Gini coefficient has a significant growth from

[72] 'Gini Coefficient': Gini=0 means complete equality; Gini=1 means complete inequality; usual range is from 0.2-0.3 (low)

1980s (0.395 in 1988) to 1990s (0.469 in1995) and remains stable over 1990s (0.468 in 2002); however, the inequality starts to widen again after 2002 (0.497 in 2007).

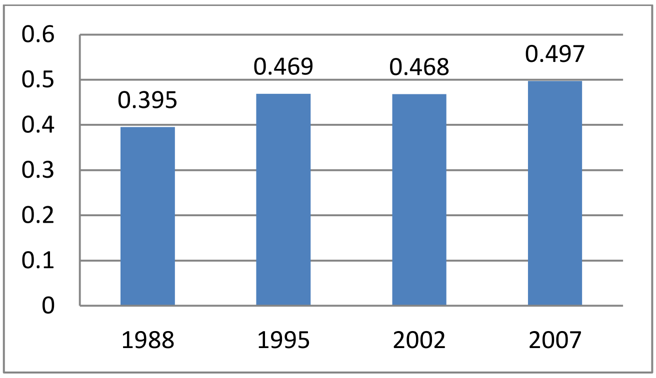


Figure 4.12: Income Inequality in China, 1988-2007 (Gini Coefficient; CHIP data)

Sicular (2011) also points out the two key factors for the wider disparity of income. The long-standing issue is the urban-rural income gap, and the other new factor is the asset income due to expansion of household wealth in the 2000s. To some extent, that reflects the house price gaps between east-coastal developed cities and west-inland developing cities. Table 4.18 discloses the evidence of the bigger urban-rural income gap attributing to the national inequity. Table 4.19 shows the driving power of the growth of share of income to the inequity via the 2002 and 2007 CHIP survey data. Further, the wider income inequality eventually contributes on the divergence of China's regional house prices.

Table 4.18: Urban-Rural Income Gap & Inequality (CHIP data)

Year	***Urban/rural income ratio***	***Contribution to national inequality***
1988	2.7	-
1995	3.1	41%
2002	3.3	47%
2007	4.1	52%-54%

Table 4.19: Asset Income & Inequality (CHIP data)

Year	***Share of income***	***Contribution to inequality***
2002	10%	9%
2007	15%	20%

to 0.5-0.6 (high).

Note: Asset income includes incomes from financial assets and imputed rental income from owner-occupied housing.

Both the unit root tests for regional-national house price ratios and α-/β- convergence method indicate that there is no significant evidence of convergence; nevertheless, there are some cities' house prices affecting other cities'. Zhang and Liu (2009) find that there is a significant long-run cointegration relationship between each two of the eight cities[73] they chose. Compared with the findings of Zhang and Liu (2009), in total 35 sample cities, our pairwise Engle-Granger cointegration tests suggest there is no long-run cointegration relationship between most of two cities pairs but only between a few specific cities, such as the two-way cointegration between Dalian and Fuzhou, Hohhot and Taiyuan, Changchun and Guiyang, Changchun and Urumchi, Nanchang and Qingdao, Shenzhen and Zhengzhou, Hohhot and Jinan.

Furthermore, the results of the Johansen system cointegration test for multivariate series indicate house prices in most cities have a long-run equilibrium relationship with core cities—Beijing, Shanghai and Guangzhou. Then, the panel regression estimations verify the indication of Johansen system cointegration test by showing that house price shocks in Beijing, Shanghai and Guangzhou affect other cities' house price changes in both the short-run and long-run term. Also, the coefficients of previous house price changes are significantly negative in the short run (in terms of quarter) and significantly positive in the long run (in terms of year). The quarterly change may be more influenced by random stochastic factors than the annual figure, which will be dominated perhaps more by the underlying trend. This suggests that the stochastic factors are corrected for, whilst the long term factors have a continuing impact.

Additionally, the panel regressions show that, the distance factors of Shanghai and Guangzhou significantly impact upon house price changes in other cities in the short run, but this effect become less significant in the long run. Interestingly too, the house price changes in Beijing have a positive effect on other cities' house prices in the short term[74] but a negative effect in the long run[75]. One explanation is that the effect of Beijing's house price change is felt more quickly than other core cities, and is not diluted by distance. Therefore when a

[73] Zhang and Liu (2009) select quarterly house price index from 1998-2007 for eight cities—Beijing, Chengdu, Harbin, Hangzhou, Nanjing, Shanghai, Shenzhen and Xi'an.
[74] See Table 4.13 with positive coefficients for Beijing.
[75] See Table 4.14 with negative coefficients for Beijing.

year's lagged effects are considered for their impact on other cities any short run changes from Beijing have filtered into the own lagged city prices and the house prices of Beijing then perform the role of a correction factor.

Next, the pairwise Granger causality test investigates the short-run relationship of house price changes between each two cities and finds complementary evidences of the significant impact of house price fluctuations in Beijing and Shenzhen; however, the panel regression models indicate their influence has weakened over time as well. The maps of Figure 4.13 and Figure 4.14 highlight which cities' house prices caused by the house prices changes of core cities in the short- (in terms of quarterly changes) and long- (in terms of yearly changes) run respectively. As shown in the maps, the purple rectangles feature core cites; in order to distinguish results of pairwise Granger causality tests, the red, green and yellow ellipses highlight the cities which are significantly affected by core cities at the 1%, 5%, and 10% significance level respectively.

According to pairwise Granger causality tests, the development of three big economic zones pulling up China's economic growth explains the effects of house price rising 'ripple out' from core cities—Beijing in BTT-EC, Shanghai and Hangzhou in YRD-EC, Guangzhou and Shenzhen in PRD-EC—to other cities. In the short run, the most influential cities are Beijing in the north, Hangzhou on the coast and Shenzhen in the south respectively; while in the long run, the most infusive cities are Beijing, Hangzhou, Shenzhen and Guangzhou. To some extent, our Granger causality findings are consistent with Zhang and Liu (2009) about '*Shenzhen being the primary original regions of nationwide house price rising*'. But we extend this to include a limited number of other influential cities. Once again, the panel regression models, based on the core cities chosen by the Granger causality tests, indicate that the increase of house price in Beijing drives up house prices in other cities in the short run but brings down other cities' house prices in the long run[76].

In summary, the unit root tests and α-/β- convergence models support the evidence of non-convergence between regional house prices of 35 cities in China from 1997 to 2010. For the record, we need notice that this is an extraordinary period of economic growth in China over this time period, and when growth stabilises in the future we may see the convergence of house prices. In the long run, the house prices in different regions do not exhibit cointegration

[76] See Table 4.16 with positive coefficients for Beijing and Table 4.17 with negative coefficients for Beijing.

relationship; however, in line with the panel regression estimations and Granger causality tests, house prices shocks in some core cities have ripple effects on other cities' house price changes, wherein Beijing, Shanghai, Hangzhou, Guangzhou and Shenzhen are original regions of nationwide house price swings.

Finally we reflect on the nature of convergence and house price differences. The latter can either be because average houses are better in A than B or the same quality house is more expensive in A than B. The latter is likely to be capable of being corrected more quickly than the former – which requires a change to the housing stock and may take decades. There is little discussion of this in the literature, but it would be interesting in future analysis to distinguish between these two aspects of convergence.

Figure 4.13: The Granger Causality Effects of Quarterly House Price Changes of Core Cites (Beijing, Hangzhou and Shenzhen) in the Short Run


Hailar
Qiqihar
Harbin
Changchun
Yining
Kuqa
Urumqi
Aksu
Korla
Turpan
Kashgar
Yellow River
Shenyang
Hohhot
Dunhuang
Jiayuguan
Beijing
Dalian
Hetian
Baotou
Yinchuan
Datong
Tianjin
Golmud
Xining
Shijiazhuang
Lanzhou
Taiyuan
Jinan
Qingdao
Zhengzhou
Tibet
Xian
Kaifeng
Luoyang
Nanjing
Suzhou
Lhasa
Hefei
Shanghai
Shigatse
Tsedang
Chengdu
Yichang
Wuhan
Hangzhou
Tingri
Gyangtse
Huangshan
Ningbo
Zhangmu
Everest
Chongqing
Changsha
Lijiang
Nanchang
Diaoyu Islands
Yangtze River
Fuzhou
Guiyang
Guilin
Dali
Kunming
Yangshuo
Xiamen
Guangzhou
Taiwan
Shenzhen
Hong Kong
Nanning
Macau
Haikou
Dongsha Islands
Sanya


Hailar
Qiqihar
Harbin
Yining
Urumqi
Kuqa
Changchun
Aksu
Turpan
Korla
Kashgar
Yellow River
Shenyang
Hohhot
Dunhuang
Jiayuguan
Beijing
Dalian
Hetian
Baotou
Yinchuan
Datong
Tianjin
Shijiazhuang
Golmud
Xining
Lanzhou
Taiyuan
Jinan
Qingdao
Zhengzhou
Tibet
Xian
Kaifeng
Luoyang
Nanjing
Suzhou
Lhasa
Hefei
Shigatse
Tsedang
Chengdu
Yichang
Shanghai
Hangzhou
Tingri
Gyangtse
Wuhan
Huangshan
Ningbo
Zhangmu
Everest
Chongqing
Changsha
Lijiang
Nanchang
Diaoyu Islands
Yangtze River
Fuzhou
Guiyang
Guilin
Dali
Kunming
Yangshuo
Xiamen
Guangzhou
Taiwan
Shenzhen
Hong Kong
Nanning
Macau
Haikou
Dongsha Islands
Sanya

Figure 4.14: The Granger Causality Effects of Yearly House Price Changes of Core Cites (Beijing, Hangzhou, Shenzhen and Guangzhou) in the Long Run


Hailar
Qiqihar
Harbin
Changchun
Shenyang
Yining
Urumqi
Kuqa
Aksu
Korla
Turpan
Kashgar
Yellow River
Hohhot
Dunhuang
Jiayuguan
Beijing
Dalian
Hetian
Baotou
Yinchuan
Datong
Tianjin
Golmud
Xining
Lanzhou
Taiyuan
Shijiazhuang
Jinan
Qingdao
Zhengzhou
Tibet
Xian
Kaifeng
Luoyang
Nanjing
Suzhou
Lhasa
Shigatse
Tsedang
Chengdu
Yichang
Hefei
Shanghai
Hangzhou
Tingri
Gyangtse
Wuhan
Zhangmu
Everest
Chongqing
Huangshan
Ningbo
Changsha
Lijiang
Nanchang
Diaoyu Islands
Yangtze River
Guiyang
Fuzhou
Dali
Guilin
Kunming
Yangshuo
Xiamen
Guangzhou
Taiwan
Shenzhen
Hong Kong
Nanning
Macau
Haikou
Dongsha Islands
Sanya


Hailar
Qiqihar
Harbin
Changchun
Shenyang
Yining
Urumqi
Kuqa
Aksu
Korla
Turpan
Kashgar
Yellow River
Hohhot
Dunhuang
Jiayuguan
Beijing
Dalian
Hetian
Baotou
Yinchuan
Datong
Tianjin
Golmud
Xining
Lanzhou
Taiyuan
Shijiazhuang
Jinan
Qingdao
Zhengzhou
Tibet
Xian
Kaifeng
Luoyang
Nanjing
Suzhou
Lhasa
Shigatse
Tsedang
Chengdu
Yichang
Hefei
Shanghai
Hangzhou
Tingri
Gyangtse
Wuhan
Zhangmu
Everest
Chongqing
Huangshan
Ningbo
Changsha
Lijiang
Nanchang
Diaoyu Islands
Yangtze River
Guiyang
Fuzhou
Dali
Guilin
Kunming
Yangshuo
Xiamen
Guangzhou
Taiwan
Shenzhen
Hong Kong
Nanning
Macau
Haikou
Dongsha Islands
Sanya

Appendix

Appendix 4.1: Original HPI (Link Index) for 35 Cities from 1998Q1 to 2010Q4

Time	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou
1998Q1	102.4	99.7	100.3	101.6	104.2	102.9	100.9	100.4	98.3	99	109.8	101.1
1998Q2	101.4	100.4	100.6	104.6	101.5	103.1	99.3	100.4	101.1	98.5	106.5	103.2
1998Q3	99.8	101.1	100.5	102.8	100.5	101.9	101.4	100.3	98.5	93.8	102.5	102.8
1998Q4	100	101.2	101.3	104.5	106.8	101.4	96.2	100.5	99.1	91.5	102	103.3
1999Q1	99.9	100.5	103.9	97.4	100.7	101.8	102.6	101.6	99	96.3	101.5	104.3
1999Q2	100.5	99.6	103.9	97.6	95.3	101.8	101.7	103.8	99.4	93.9	100.6	102
1999Q3	100.2	99.8	103.8	98.7	98.3	100.7	101	101.1	101.8	95.8	102.4	103.3
1999Q4	99.7	99.9	103.3	97.6	98.6	102.7	104.4	111.8	100.6	98.6	101.9	102.3
2000Q1	100.3	99.8	101.2	101.7	101.5	102.4	98.2	100.7	99.3	98.5	100.8	102.2
2000Q2	99	100	101.3	100.8	103.2	103.5	102.2	102.2	101.3	98.6	100.9	106.9
2000Q3	99	100	101.9	100.4	101.1	103.9	95.8	108.1	104.4	97.8	102	105.6
2000Q4	99.7	100	102.9	101.5	102	102.1	104.7	109.5	102	99.5	102.7	104.7
2001Q1	101.6	100.2	103.3	101.1	102.4	104.2	100.7	104	100.5	100	99	106.3
2001Q2	101.3	102.3	104.1	100.5	103.7	102.4	100.3	104.1	101	104.7	102.2	107.2
2001Q3	101.1	101.4	105.2	100.2	103.1	102	100.6	102.3	103.6	107.8	100.7	105.4
2001Q4	101	100.7	103.1	99.1	100.3	101.9	96.6	100.1	102.5	105.1	100.2	104.3
2002Q1	99.9	101.1	103	103.2	103.1	101.3	94.4	101.7	102.9	105.7	102	105.5
2002Q2	101.4	101.3	102.1	103.2	101.5	99.9	99.5	94.4	100.5	106	103.9	106.9
2002Q3	100.8	102.2	100.5	103.5	103	99.2	99.8	96.3	101.1	107.9	103.5	108.4
2002Q4	99	101.6	100.1	103.4	101.7	99.9	99.9	96.5	99.8	109.7	102.5	106.6
2003Q1	100.2	101.5	100.2	102.8	101.1	101.4	98.5	101.2	100.1	111.8	107.4	104.3
2003Q2	100.2	102.8	99.7	102.2	100.5	103.8	102.2	101.2	100.1	118.1	109.5	105.4
2003Q3	100.2	104.6	100.1	102.6	100.3	109.4	101.5	100.1	100	121.5	108.9	105.6
2003Q4	100.6	107.5	101	103.6	100.7	115.8	100.4	99.3	100.6	129.1	113.4	109
2004Q1	101.8	114.2	102.2	104.4	101.4	119.6	103.4	97.5	101.1	128.3	112.1	110.5
2004Q2	103.3	116.7	104	103.6	105	112.8	103.8	99.9	109.2	121.4	116.2	113
2004Q3	103.5	113.4	104.5	108.7	106.9	119.2	106.9	101.9	104.4	114.9	117.7	110.1
2004Q4	106.3	109.5	103.5	108.8	107.3	112	104.1	101.3	104.1	110.4	115.2	113.4
2005Q1	106.5	106.5	106.5	101.5	107.7	109.3	107.2	99.2	104.8	119.1	111.6	113.8
2005Q2	106.5	106.1	106	109.3	112.2	107.6	108.7	102.1	104	111.6	107.9	112.5
2005Q3	106.3	105.7	104.3	107.9	113.5	107	108.3	104.2	104.2	106.5	107.7	107.4
2005Q4	107.4	105.6	105.4	103.7	103.7	106.1	112.4	102.2	105.4	101.7	105	105.4
2006Q1	107.1	105.8	106.1	101.9	112.4	106.6	114.9	101.8	103	98.7	104.8	102
2006Q2	108.7	106.7	104.5	104.1	111.3	106.6	111.9	101.5	103.4	97.2	104.1	102.8
2006Q3	109.7	107.1	103	105.1	108.3	106.3	108.5	101.2	103.4	98.9	103.8	102.6
2006Q4	109.5	107.2	103.8	104.5	105.8	106.8	108.2	102.1	103.2	99.9	104.7	103.3
2007Q1	109	106.9	105	103.7	104.4	106.4	107.2	102.9	105	100.2	105.5	102.9
2007Q2	109.5	106.7	107.5	104	104.1	105.2	106.9	104.7	106.3	100.8	107	104.1
2007Q3	111.9	106.8	108	105	104.3	105.2	107	107.7	105.2	103.9	106.7	108.8

2007Q4	115	107.3	110	104.9	104.6	107.7	107.6	110.3	110.6	108.7	107.3	113.3
2008Q1	113.9	106.9	109.9	105.1	100.6	109	106.8	111.3	109.4	109.8	106.9	113.7
2008Q2	112.2	107.2	108.1	106.3	101.3	105.9	105.6	108.6	107.3	109.3	105	112.7
2008Q3	108.7	106	104.4	106.5	102	102.8	104.4	104.8	105.6	105.3	101.8	106.9
2008Q4	103	103.2	100.6	105	101.1	100.6	102.5	103.2	103.1	99.3	97.3	101
2009Q1	99.3	101.6	96.4	102.3	99.6	101.2	100.2	101.2	101.9	97.8	96.5	99.6
2009Q2	99.1	101.1	94.3	100.2	99.2	101.7	99.5	100	102.1	98.6	97.3	99.2
2009Q3	101.1	103.4	95.5	99.5	99.7	101.4	101.5	101	102.7	101.2	101.7	103
2009Q4	105.9	106.7	99.4	100.5	101.9	101.5	103.6	102.2	104.4	105.6	108.3	109.2
2010Q1	111.1	110.1	105.2	103.0	106.6	103.0	106.8	105.2	106.1	109.5	110.9	113.3
2010Q2	114.2	111.6	109.5	104.4	109.4	106.0	110.0	107.4	107.4	110.2	110.9	115.7
2010Q3	111.8	108.7	109.9	103.8	108.8	107.0	107.7	105.1	106.9	106.1	105.9	109.6
2010Q4	108.8	106.6	108.4	103.0	107.7	108.1	106.9	104.3	106.3	103.2	102.5	102.7

HPI (Link Index) for 35 cities from 1998Q1 to 2010Q4 (con.)

Time	Ningbo	Hefei	Fuzhou	Xiamen	Nanchang	Jinan	Qingdao	Zhengzhou	Wuhan	Changsha	Guangdong	Shenzhen
1998Q1	100.7	101.4	98.1	102.5	99.5	101.6	97.9	108.5	105.2	103.7	102.9	102.9
1998Q2	99.7	104.6	104.6	101.4	100.8	101.6	101.1	112.5	102.6	103.6	97.7	100.8
1998Q3	99.9	102.1	100.9	98.6	101.5	101.1	100.5	103.4	104.4	102.2	99.2	96.3
1998Q4	98.6	98.8	100.8	99.8	100.2	101.5	100.9	102.1	98.7	102.2	96.9	98.3
1999Q1	99.6	98.8	101.5	99.7	103.9	101.6	101.7	99.6	95	97.4	94.4	98.2
1999Q2	97.5	99.6	101.4	99.6	99.3	101	103.1	101.2	99.1	99.2	91.6	98
1999Q3	102.4	99.1	99.3	100.8	102.3	102	102.8	100.9	99.4	99.4	98.7	96.5
1999Q4	102.9	99.9	97.3	101.9	100.9	101.3	107.1	102.7	101	97.9	95.8	98.5
2000Q1	103.3	100.5	102.7	98.1	102.5	101.6	99.3	100.8	100.7	97.7	95.7	98.7
2000Q2	106.9	100.3	100	100.2	103.3	103	102.8	101.3	100.3	99.8	96.7	99.4
2000Q3	105.2	99.5	99.4	100.7	104.4	104.2	103.7	97.5	101.1	100.4	98.2	99.5
2000Q4	106.5	99.8	99.2	101.6	102.4	102.5	103.3	98.5	103.1	100.3	98.7	99.2
2001Q1	104.7	100.3	99.8	100.5	103.7	101.6	109.3	100.6	111.2	102.3	100	98.5
2001Q2	106.5	100.4	100.9	100.3	102.5	102	103.7	100.2	111.7	101.7	100.5	102.2
2001Q3	108.5	100.8	100.3	104.1	105.2	102	101	100.7	100.9	102.3	100.4	102.1
2001Q4	109	100.4	102.8	103.9	104.5	101.6	102.2	100.8	100.6	102.2	100.3	101.2
2002Q1	112.5	104	99.9	102.2	109.3	101.5	104.7	101.3	101.2	101.2	101.2	100.5
2002Q2	115.9	104.4	100.8	102.9	113	101.2	105.4	101.5	101.5	101.6	98.8	100.8
2002Q3	119.2	103.5	101.7	104.4	109.5	104.4	108.7	101.6	103.3	101.5	98.9	100.4
2002Q4	117.8	103.9	102	102.6	114.6	103	111.5	103.3	101.6	100.1	99.6	99.9
2003Q1	120.6	105.5	101.6	102.3	105.9	101.6	111.4	102	104.8	99.8	100.8	101.8
2003Q2	116.4	104.9	101.3	102.4	103.1	102.3	113.4	102.3	103.5	100.2	99.4	101
2003Q3	116.1	103	100.6	102.4	103.9	103.2	115.9	101.2	102.4	100.7	99.2	102.4
2003Q4	113.4	102.9	101	104	106.1	105.2	117.6	102.3	104.5	101.2	97.8	103.5
2004Q1	111.9	108.5	102.4	108	106.9	110.2	116	102	105.9	101.2	101.3	103.4
2004Q2	119.9	107.2	103.1	104.8	105.7	107.6	112.5	103.1	110	104.9	102	103.7
2004Q3	112.5	101.5	104.1	106.5	108.2	109.6	112.9	104.7	109.9	103.8	102.3	104.4

2004Q4	111.1	105.2	104.9	109.7	108.5	113.7	119.8	106.2	107.8	103.3	105	106.8
2005Q1	111.6	109.7	106	112.4	108.6	108.7	111.7	107.4	111.2	101	104.8	106.3
2005Q2	106.2	104.7	104	109.5	110.3	106.7	112.4	107.6	106.6	101.7	105.9	105.9
2005Q3	104.7	106.4	104.2	104.7	108.4	107.7	111.1	107.5	105.7	104.2	104.3	106.5
2005Q4	102.6	103.8	103.4	105.4	105.9	107.1	108.5	105.4	103.8	104.4	103.6	110.2
2006Q1	102.6	102.3	104.1	105.2	105.7	105.2	107.8	105.9	103.1	104.5	104.5	110.2
2006Q2	101.7	101.7	107.7	107	106.7	103.8	107	105.3	103.2	105.7	107.1	114.4
2006Q3	102.1	100.6	107	108	106.7	104	106.8	105.1	103	105.1	106.2	112.8
2006Q4	102.2	100.4	107.8	107.6	105.8	104.1	106.1	106.5	102.8	105.9	107	111.8
2007Q1	104.5	100.4	107.2	107.2	106.1	103.8	105.2	106.4	103.2	106	108	112.6
2007Q2	106	100.9	106.1	106.3	106.7	104.8	105.9	106.3	104.3	106.5	105.7	114.3
2007Q3	109.4	101.4	106.3	106.8	106.9	105.4	107	106.5	105.6	108.1	106.5	120.2
2007Q4	114.5	104.4	107.5	107.6	107.6	106.6	108.1	106.1	107.7	112.9	106.3	118.2
2008Q1	114.6	110.5	107.2	106.5	107.7	107.4	106.6	105.8	108.2	111.5	103.1	111
2008Q2	112	110.9	105.1	105	105.5	108.3	106.3	103.9	106.5	108.9	102	102.5
2008Q3	108.3	109.2	102.7	102.3	101.9	108.2	105.1	102.4	104.2	105.5	98.6	93.2
2008Q4	101.7	102.9	100.3	97	101.5	105	102.4	101.3	100.7	100.7	95.6	85.8
2009Q1	100.7	99.2	99.6	95.6	100.1	101.9	99.2	101.3	98.2	99.3	95.7	85.1
2009Q2	101.9	98.8	99.8	97.1	100.2	100.8	98.8	101.5	97.8	99.3	96.7	94.7
2009Q3	104.6	99.9	100.4	100.7	102.1	101	100.3	102.2	98.6	100.6	101.4	106.8
2009Q4	106.6	102.1	101	105.7	104	103.1	102.8	103.2	100.9	105	106.9	116.4
2010Q1	108.0	107.0	103.4	109.1	107.9	105.8	106.9	105.3	105.0	110.2	110.7	120.5
2010Q2	106.9	110.9	103.9	107.8	109.3	106.5	108.1	108.0	108.4	111.2	107.6	114.2
2010Q3	105.2	108.2	103.0	103.6	105.9	106.4	106.3	108.0	108.4	108.7	102.9	104.5
2010Q4	102.6	108.7	102.9	102.4	106.2	105.4	106.3	108.8	107.6	107.7	100.5	102.2

HPI (Link Index) for 35 cities from 1998Q1 to 2010Q4 (con.)

Time	Nanning	Haikou	Chongqing	Chengdu	Guiyang	Kunming	Xi'an	Lanzhou	Xining	Yinchuan	Urumchi	Nation
1998Q1	101.5	98.7	110.6	102.9	110.1	100.6	99.2	97.1	99.7	105.6	100.5	101.3
1998Q2	101.1	99	106.7	104.4	106.7	100.1	100.9	97.7	101.4	110.2	104.5	102.1
1998Q3	95.6	102.1	104.7	105.6	108.7	100.5	101.1	100	103.5	115.4	104.7	101.3
1998Q4	95.9	106	103.7	105.3	106.7	104.3	100.6	99.1	101.4	113.5	102.8	101
1999Q1	89.4	96.2	103.7	105.6	103	102.2	99.4	103.8	100.2	109.8	103.3	99.7
1999Q2	101.2	98.6	103.7	105.8	103.6	105.2	99.8	101.2	101.6	109.4	109.5	99.6
1999Q3	98.7	96.2	102.9	106	103.9	101.3	100.9	99.8	102.1	100.9	100.1	99.9
1999Q4	102.4	92.5	102.7	95.9	102.5	100.6	101.3	101.2	100	104.3	101.2	100.7
2000Q1	103.5	98.2	102	100.5	103.8	99.9	101.5	100.1	102	99.1	101.8	100.7
2000Q2	100.1	99.8	101	100.7	103.5	99.1	101.6	99.7	100.9	101.8	102.4	101.1
2000Q3	99.4	98.8	101.4	103.9	102.8	101.5	101.2	102.1	99.5	104.4	102.6	101.5
2000Q4	94.2	100.9	102.7	100	105.3	100.3	100.9	100.1	101.8	103.4	102.7	101.2
2001Q1	101.5	99.1	99.2	101.5	98.8	101.5	101.2	103.4	100.3	103.5	101.2	101.9
2001Q2	102.2	99.3	100.7	99.2	99	102.2	101.6	103.4	99.8	104.6	101.2	102.5
2001Q3	102.2	100.5	100.1	100.7	100.8	101.3	103.4	101.5	101.6	103.8	100.7	102.7

2001Q4	100.5	100.4	101.3	101.7	100.1	100.4	101.3	101.9	100.4	104.7	100.7	101.8
2002Q1	100.6	100.8	101.5	101.8	100.5	101	101	104.5	102.3	102.8	98.7	104.3
2002Q2	102.7	104.5	101.4	100	102	98.9	101.1	102.5	101.6	103.4	99.3	102.8
2002Q3	102.3	100.2	101.8	102	102.5	99.5	101.1	104.6	103.2	104.8	99.7	104
2002Q4	104.2	102.1	101.4	101.2	100.4	103.5	101.2	105.4	101.7	103.5	99.1	103.5
2003Q1	101.8	103.7	106.8	101.3	100.6	99.3	101.4	100.5	102.3	102.5	99.6	104.8
2003Q2	101.7	100.7	105.5	101.8	101.6	99.3	101.1	100	101.5	102.1	99.9	105
2003Q3	103	102	101.3	102.5	101.3	97.3	101.4	100.4	101.3	101.4	99.8	104.1
2003Q4	101.7	104.3	110.9	105.9	101.5	100.3	101.7	106.1	102.5	102.2	100.4	105.1
2004Q1	102.6	108.9	114.5	105.5	102.1	100.1	104.5	104.4	104.5	103.9	100.3	107.7
2004Q2	106	106.6	115	106.4	103	100.9	104	108.6	104.9	103.9	101	110.4
2004Q3	107.1	105.1	115.6	108.3	102.3	104.6	106.6	113.1	103.3	104.8	101	109.9
2004Q4	107.1	102.8	110.3	111.4	102.8	103.4	104.9	108.7	103.4	104.8	100.4	110.8
2005Q1	107.6	104	107.8	112.5	102.9	104.6	104.7	106	103.3	103	101.9	109.8
2005Q2	102	104.2	107.6	110.7	102.8	102.4	103.7	105.1	104.1	102.7	101	108
2005Q3	104.6	102.5	108.1	101.6	103	106.9	104.2	105.4	102.5	102.3	100.7	106.1
2005Q4	105.5	99.4	107.8	103.1	101.6	106.5	104.5	105.7	103.5	102.6	100.1	106.5
2006Q1	104.9	101.7	103.5	108	104.2	102.1	103.3	105.6	102.4	101.9	100.4	105.5
2006Q2	104.1	102.7	102.7	106.2	103.7	102.1	103.5	104.1	104	102.2	101.1	105.7
2006Q3	103.8	104.1	102.1	107.3	104.9	100.5	103.6	104.5	102.2	102.4	101.3	105.5
2006Q4	103.6	102.7	103.7	107	104.8	100.6	103.9	104.6	102.6	102.8	102	105.3
2007Q1	104.3	103.3	103.3	106.7	106.6	102.2	104.4	104.5	102.7	102.5	102.1	105.6
2007Q2	105.7	104.1	104	106.7	106.5	103.3	105.1	104.6	103	103.2	104	106.3
2007Q3	108.4	108.6	108.3	107.6	106.6	103.5	106	105.6	103.6	104.1	112.3	108.2
2007Q4	111.9	110.3	112.1	109.3	107.9	105	110.1	109.2	105.7	105.9	117.7	110.2
2008Q1	114.5	112.1	113.1	107.9	110.9	105.8	111.1	113	109	109.4	124.5	111
2008Q2	110.8	112.4	111.2	105.1	106.4	106.1	110.2	111	108.2	113.1	120.9	109.2
2008Q3	105.9	110.8	105	102.2	105	101.3	108.2	110.2	107.9	113.9	111.5	105.3
2008Q4	101.4	106.5	95.9	98.4	104.1	99.6	102.7	104.9	104.9	110.7	105.1	100.5
2009Q1	100.2	101.3	98.4	97.5	103	97.4	100	103.7	104.5	107	102.4	98.9
2009Q2	99.3	99.4	99.4	99.1	103	97.6	98.6	104.5	104.1	103.7	101.5	99.5
2009Q3	99.9	101.6	101.4	101.1	103.4	102.5	99.4	103.6	104	105.1	101.6	101.9
2009Q4	102.9	106.8	105.2	103.9	104.8	106.6	104	104.6	104.9	108.4	104.2	105.8
2010Q1	106.3	145.4	110.3	105.7	110.0	109.4	111.2	105.3	106.1	113.8	106.8	110.6
2010Q2	107.3	152.2	111.1	105.8	109.3	107.4	113.7	106.5	107.2	114.5	107.5	112.2
2010Q3	105.2	146.3	109.5	104.0	107.7	105.1	113.5	106.6	106.7	110.6	107.4	109.6
2010Q4	102.9	139.4	107.8	102.4	105.7	105.2	110.0	110.8	106.4	106.3	108.3	107.6

Appendix 4.2: Univariate Unit Root Tests of LHP and DLHP

City Code	City	ADF Test by SIC			ADF Test by Fixed Lag 4		DF-GLS test	KPSS test	1st Difference ADF Test by SIC			2nd Difference ADF Test by SIC	
		t-Statistic	Prob.	Lag Length	t-Statistic	Prob.	t-Statistic	LM-Stat.	t-Statistic	Prob.	Lag Length	t-Statistic	Prob.
1	Beijing	-1.029318	0.9304	5	-1.464999	0.8287	-1.452419	0.302276***	-2.962352	0.0455**	4	-	-
2	Changchun	-1.343898	0.8653	4	-	-	-1.559360	0.188310**	-3.296185	0.0202**	3	-	-
3	Changsha	-0.803546	0.9583	5	-1.675246	0.7478	-1.170187	0.301367***	-3.887771	0.0199**	4	-	-
4	Chengdu	-1.906791	0.6365	4	-	-	-1.693224	0.199176**	-2.856344	0.0577*	3	-	-
5	Chongqing	-2.774470	0.2131	4	-	-	-2.601997	0.186601**	-9.659912	0.0000***	1	-	-
6	Dalian	-1.822337	0.6792	4	-	-	-1.204748	0.279224***	-2.215614	0.2034	3	-15.28451	0.0000***
7	Fuzhou	-1.619090	0.7715	4	-	-	-1.062191	0.265244***	-2.752513	0.0724*	3	-	-
8	Guangzhou	-2.446602	0.3523	5	-2.949921	0.1562	-1.956520	0.269723***	-2.513278	0.0129**	4	-	-
9	Guiyang	-0.815780	0.9572	4	-	-	-1.417182	0.243950***	-2.893129	0.0531*	3	-	-
10	Haikou	1.744813	1.0000	7	0.847784	0.9997	-0.839884	0.259771***	-4.311433	0.0067**	6	-	-
11	Hangzhou	-2.438818	0.3560	5	-3.357816	0.0687	-2.149520	0.159258**	-4.872118	0.0002***	4	-	-
12	Harbin	-1.286141	0.8802	4	-	-	-0.615669	0.304541***	-3.871160	0.0206**	3	-	-
13	Hefei	-2.092863	0.5372	4	-	-	-1.262627	0.205380**	-3.897092	0.0194**	4	-	-
14	Hohhot	-2.226056	0.4654	4	-	-	-1.891655	0.204626**	-1.831411	0.0624*	3	-	-
15	Jinan	-2.445689	0.3528	4	-	-	-1.697986	0.248797***	-2.221130	0.2015	3	-33.18464	0.0001***
16	Kunming	-1.232432	0.8928	4	-	-	-1.266955	0.265244***	-3.092985	0.0334**	3	-	-
17	Lanzhou	-1.444063	0.8356	4	-	-	-0.564178	0.298095***	-3.631871	0.0369**	3	-	-
18	Nanchang	-2.953651	0.1545	0	-2.295859	0.4285	-1.519359	0.159233**	-10.28841	0.0000***	0	-	-
19	Nanjing	-3.291746	0.0792	4	-	-	-2.630463	0.154371**	-6.983502	0.0000***	0	-	-
20	Nanning	-3.131748	0.1101	4	-	-	-1.070379	0.281038***	-3.298903	0.0201**	3	-	-
21	Ningbo	-2.580518	0.2905	4	-	-	-2.527444	0.1333827*	-1.833218	0.3607	3	-12.96781	0.0000***
22	Qingdao	-2.012686	0.5805	4	-	-	-1.818012	0.156452**	-2.322951	0.1689	3	-23.10393	0.0001***
23	Shanghai	-3.073971	0.1234	4	-	-	-2.666208	0.137716*	-1.837392	0.0634*	4	-	-
24	Shenyang	-2.986865	0.1459	4	-	-	-2.399959	0.177940**	-1.886688	0.3358	3	-21.38357	0.0001***
25	Shenzhen	-1.791848	0.6950	1	-2.449486	0.3509	-1.795204	0.250172***	-5.864887	0.0000***	0	-	-

26	Shijiazhuang	-1.723282	0.7261	5	-2.955336	0.1547	-2.729346	0.196307**	-5.024282	0.0001***	4	-	-
27	Taiyuan	-1.982907	0.5965	4	-	-	-1.187578	0.254852***	-3.321254	0.0190**	3	-	-
28	Tianjin	-2.335285	0.4079	5	-2.235837	0.4602	-1.515111	0.264810***	-3.911556	0.0187**	4	-	-
29	Urumchi	-1.457822	0.8320	0	-1.429980	0.8400	-1.631389	0.244153***	-10.49693	0.0000***	0	-	-
30	Wuhan	-3.401811	0.0624	4	-	-	-3.152068*	0.150755**	-2.775462	0.0689*	3	-	-
31	Xi'an	-0.671596	0.9696	6	-0.848729	0.9538	-0.802348	0.305233***	-3.208802	0.0253**	4	-	-
32	Xiamen	-2.904259	0.1699	4	-	-	-1.654709	0.223252***	-3.041794	0.0378**	4	-	-
33	Xining	0.240907	0.9978	4	-	-	-0.504942	0.301826***	-3.882154	0.0200**	3	-	-
34	Yinchuan	-1.446344	0.8337	8	-1.642773	0.7617	-1.899340	0.179522**	-3.281620	0.0811*	4	-	-
35	Zhengzhou	-1.992681	0.5912	4	-	-	-1.966402	0.261747***	-2.083420	0.2520	3	-12.91683	0.0000***

Notes:
(1) The null of ADF and DF-GLS tests is ‘unit root’, the null of KPSS test is ‘stationary’.
(2) All the tests choose the model with ‘intercept and trend’.
(3) The ADF tests take the lag by both SIC and fixed lag 4.
(4) The DF-GLS and KPSS tests take the fixed lag 4.
(5) The ADF tests for 1^{st} difference LHP take the lag by SIC.
(6) The ADF tests for 2^{nd} difference LHP take the lag by SIC, but SIC choose lag 2 for all of them.
(7) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.

Appendix 4.3: Univariate Unit Root Tests of LHP without Trend

City Code	City	ADF test		DF-GLS test	KPSS test
		t-Statistic	Prob.	t-Statistic	LM-Stat.
1	Beijing	0.615411	0.9889	0.207294	1.066271***
2	Changchun	0.209322	0.9707	0.672957	1.066974***
3	Changsha	1.404123	0.9988	0.756016	1.083967***
4	Chengdu	-0.193875	0.9323	0.330354	1.174042***
5	Chongqing	0.624070	0.9891	1.143201	1.200336***
6	Dalian	0.667103	0.9902	0.374778	1.072810***
7	Fuzhou	0.293730	0.9758	0.079164	1.116677***
8	Guangzhou	-0.896452	0.7815	1.002222	0.792791***
9	Guiyang	1.697021	0.9995	1.862717*	1.154808***
10	Haikou	2.08535	0.9999	0.881753	0.947727***
11	Hangzhou	-0.269749	0.9219	-0.232993	1.213994***
12	Harbin	1.813928	0.9997	0.490600	1.126852***
13	Hefei	0.999838	0.9960	1.032860	1.170507***
14	Hohhot	0.660646	0.9901	1.027801	1.175000***
15	Jinan	0.389525	0.9806	0.171446	1.197820***
16	Kunming	1.063798	0.9967	1.014886	1.132102***
17	Lanzhou	1.718117	0.9996	0.694580	1.162698***
18	Nanchang	0.001929	0.9538	0.193682	1.209980***
19	Nanjing	-0.069665	0.9470	0.293022	1.190734***
20	Nanning	0.939073	0.9953	0.558555	1.096690***
21	Ningbo	-1.219409	0.6592	-0.836428	1.192148***
22	Qingdao	-0.732278	0.8291	-0.384173	1.190695***
23	Shanghai	-1.118395	0.7017	-0.834409	1.115575***
24	Shenyang	-0.072735	0.9467	0.234283	1.189761***
25	Shenzhen	-0.042656	0.9498	-0.006606	1.050406***
26	Shijiazhuang	0.085377	0.9615	0.578062	1.190002***
27	Taiyuan	0.827668	0.9936	0.843739	1.176514***
28	Tianjin	0.368445	0.9796	-0.003897	1.154141***
29	Urumchi	0.116227	0.9640	0.107566	0.975830***
30	Wuhan	0.411986	0.9816	1.037489	1.214371***
31	Xi'an	1.874882	0.9997	1.009798	1.141473***
32	Xiamen	0.040557	0.9577	0.032718	1.160516***
33	Xining	2.760561	1.0000	0.775389	1.153168***
34	Yinchuan	0.741594	0.9920	1.060464	1.170708***
35	Zhengzhou	1.927041	0.9998	2.033935**	1.178520***

Notes:
(1) The null of ADF and DF-GLS tests is ‘unit root’, the null of KPSS test is ‘stationary’.
(2) All the tests choose the model with ‘intercept and trend’.
(2) All unit root tests take the lags of 4.
(3) ***, ** and * indicate significance at 1%, 5% and 10% level respectively, which means to reject H_0 at 1%, 5% and 10% level respectively.

Appendix 4.4: Pairwise Engle-Granger Cointegration Tests for HPI

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
2	×	-	×	×	×	×	×	×	**	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	**	×	×	×	×	×	×
3	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
4	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
5	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
6	×	×	×	×	×	-	***	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
7	×	×	×	×	×	***	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	*	×	×	×
8	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
9	×	**	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
10	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
11	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
12	×	×	×	×	×	×	×	×	*	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
13	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
14	×	×	×	×	×	×	×	×	×	×	×	×	×	-	**	×	×	×	×	×	×	×	×	×	×	×	***	×	×	×	×	×	×	×	×
15	×	×	×	×	×	×	×	×	×	×	×	×	×	*	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
16	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
17	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
18	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	*	×	×	×	×	×	×	×	×	×	×	×	×	×
19	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
20	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
21	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×
22	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	*	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×	×
23	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×	×
24	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	×	×
25	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×	*
26	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×	×
27	×	×	×	×	×	×	×	×	×	×	×	×	×	***	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×	×
28	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×	×

29	×	**	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×	×
30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×	×	×
31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	*	×	×
32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×	×	×
33	×	*	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	*	×
34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	-	×
35	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	*	×	×	×	×	×	×	×	×	×	-

Notes:

1) Pairwise Engle-Granger Cointegration Tests: lag specification by SIC.

2) The null hypothesis is ‘series are not cointegrated’.

3) The trend specification is ‘linear trend’.

4) Mackinnon (1996) p-values.

5) If there is cointegration between two cities, it means ‘city in the row is cointegrated with city in the column’.

6) When run the Pairwise Engle-Granger Cointegration test, add seasonal dummy variables (s1 s2 s3) into the regression.

7) ‘***, **, and *’ indicate significance at 1%, 5%, and 10% level respectively, which means ‘***, ** and *’ reject the null hypothesis at 1%, 5%, and 10% level respectively; ‘×’ indicates ‘fail to reject the null’, which means ‘series are not cointegrated’.

Appendix 4.5: Pairwise Granger Causality Tests for First Difference of LHP

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	-	*	***	×	**	***	***	**	***	**	***	***	×	***	**	***	***	**	×	***	***	***	×	**	×	***	×	***	**	***	***	***	*	***	***
2	*	-	***	**	***	×	***	***	**	***	×	***	***	×	***	×	**	*	×	**	×	×	***	***	×	***	***	***	×	**	**	**	**	×	×
3	***	*	-	***	×	**	**	**	***	×	***	***	×	***	×	***	***	×	**	**	**	***	×	×	**	**	×	**	×	*	***	×	***	***	×
4	**	***	*	-	×	**	**	*	**	×	*	***	***	***	***	×	***	×	×	*	×	×	**	***	×	×	***	**	×	***	***	**	***	×	×
5	*	***	×	***	-	**	×	***	×	***	×	***	***	×	**	×	×	**	×	*	×	×	***	***	*	***	**	***	×	×	×	×	×	×	×
6	×	×	***	×	***	-	***	***	*	×	×	×	×	***	×	***	***	**	*	**	***	***	×	**	×	×	**	*	×	**	**	**	×	**	×
7	***	***	×	***	×	×	-	***	×	**	×	***	*	×	***	×	×	*	×	**	×	×	**	***	*	×	**	***	×	×	×	×	×	×	*
8	***	×	×	*	**	×	***	-	*	*	×	***	×	×	***	***	×	×	**	×	×	**	×	***	×	×	**	***	×	×	×	×	*	***	×
9	*	*	*	×	×	×	×	×	-	×	**	***	***	*	***	×	×	×	**	×	**	×	×	**	×	×	***	**	×	×	**	×	×	×	×
10	***	×	×	×	×	×	×	***	×	-	×	***	×	×	***	×	×	*	×	×	×	×	**	***	×	×	**	***	×	×	×	*	×	×	×
11	**	***	***	×	***	×	***	×	***	**	-	***	**	***	*	***	***	*	*	***	***	***	×	×	*	×	×	*	×	***	***	***	×	***	×
12	***	***	×	***	×	×	**	**	***	***	×	-	***	***	***	*	*	×	***	×	×	***	**	×	×	×	***	×	×	**	*	**	×	**	***
13	×	***	×	***	***	×	*	***	×	**	×	***	-	×	***	×	×	**	×	×	×	×	***	***	×	***	***	***	×	×	*	**	×	×	***
14	×	×	***	**	**	***	***	×	*	×	***	***	×	-	**	***	***	*	***	**	***	***	×	*	**	×	×	*	×	***	**	*	***	***	×
15	*	***	×	***	***	×	***	***	***	***	×	×	***	×	-	×	×	*	×	×	×	×	***	***	**	***	***	***	×	×	×	***	**	×	***
16	***	**	***	***	×	***	×	×	×	×	***	**	×	***	×	-	***	**	***	×	***	***	×	×	×	×	×	×	×	**	×	×	***	***	**

17	***	×	***	***	×	***	×	×	×	×	***	×	×	***	*	***	-	**	×	×	***	***	×	×	×	×	×	***	×	×	*	×	***	***	×
18	**	×	×	**	**	×	×	×	×	**	×	×	**	×	×	×	*	-	×	×	**	*	×	×	×	×	×	**	*	×	×	***	*	***	×
19	**	×	×	**	**	×	*	**	×	×	×	***	×	***	×	***	**	×	-	*	×	***	×	×	×	×	×	**	×	×	***	*	×	***	***
20	×	***	**	***	×	×	*	×	*	×	***	***	×	×	×	×	×	×	**	-	×	×	×	×	×	×	×	×	×	×	×	×	×	**	×
21	×	×	***	*	*	***	**	×	×	×	***	*	×	**	×	×	***	**	***	×	-	***	×	×	×	×	×	×	×	×	**	×	**	***	×
22	**	×	***	*	×	***	×	×	**	×	***	×	×	×	×	×	×	×	***	×	***	-	**	×	**	*	×	×	*	***	×	×	***	***	*
23	*	×	×	***	×	×	×	×	×	×	*	***	**	×	***	×	*	×	*	×	***	×	-	***	×	×	**	***	×	×	*	×	×	×	×
24	×	***	×	***	***	×	***	***	***	***	×	***	***	×	***	×	×	×	*	×	×	×	***	-	×	***	***	***	×	×	**	***	×	×	***
25	**	×	***	***	***	×	***	***	***	***	×	**	×	***	×	***	*	**	**	***	×	***	**	*	-	***	×	***	***	*	***	***	×	**	**
26	×	*	×	***	×	**	×	×	**	**	×	***	×	×	***	×	×	×	×	×	×	×	***	***	×	-	***	**	**	×	×	×	**	×	×
27	×	***	×	***	**	×	*	***	×	×	×	***	×	×	***	×	×	×	×	×	×	×	***	***	*	***	-	***	×	×	***	***	×	×	***
28	***	***	×	***	**	**	×	***	×	**	×	***	***	×	***	×	×	*	×	×	×	×	***	***	×	*	***	-	×	×	*	×	×	×	***
29	×	×	**	×	*	×	×	*	*	×	×	**	×	***	×	***	×	×	×	*	*	***	×	×	×	×	**	×	-	*	**	×	*	***	×
30	***	×	***	**	×	***	×	×	**	×	***	***	×	***	×	×	***	×	***	×	***	***	×	×	×	×	×	×	×	-	***	×	***	***	×
31	**	**	***	**	***	×	***	×	×	***	×	***	***	×	***	***	***	×	**	×	×	**	*	×	**	***	**	***	×	×	-	**	**	**	***
32	***	***	×	***	×	*	***	***	**	**	×	***	**	×	***	*	×	**	×	×	×	*	**	***	×	**	**	***	×	×	**	-	×	×	×
33	×	***	***	***	×	**	**	×	×	×	*	×	**	***	***	×	***	×	**	×	*	***	×	×	×	×	×	×	×	***	×	×	-	***	***
3	×	×	**	×	**	**	×	**	×	×	**	**	×	**	×	**	×	×	**	**	×	**	×	×	**	×	×	×	**	×	**	×	×	-	**

4			*			*		*			*			*		*			*						*				*						
35	×	×	***	×	**	×	**	***	***	*	×	***	**	*	×	***	×	×	**	**	**	***	×	**	**	×	×	*	×	*	**	×	**	***	-

Notes:

1) Pairwise Granger Causality Tests take 2 lags.

2) The null hypothesis is ‘the city in the row does not cause the cities in the column’.

3) ***, **, and * indicate significance at 1%, 5%, and 10% level respectively, which means ***, ** and * reject the null hypothesis at 1%, 5%, and 10% level respectively.

Appendix 4.6: Pairwise Granger Causality Tests for Fourth Difference of LHP

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	-	×	***	*	×	***	***	×	***	**	***	***	***	*	**	***	***	*	**	***	**	**	**	×	**	***	*	×	**	***	***	*	***	×	***
2	**	-	×	×	×	×	**	×	×	×	×	×	×	×	×	×	×	×	***	×	×	*	×	×	×	×	×	×	×	×	×	×	×	*	×
3	×	*	-	×	×	×	×	**	**	×	×	***	**	×	**	**	***	**	**	×	*	×	*	**	×	***	×	×	×	×	***	*	***	*	×
4	×	**	×	-	×	**	×	×	×	×	×	×	×	*	×	×	×	×	*	×	×	**	×	×	×	×	**	×	×	×	×	**	×	**	**
5	*	×	*	×	-	***	×	×	×	×	×	**	***	×	***	×	**	×	×	**	***	*	*	×	×	×	**	*	×	**	**	×	***	×	*
6	*	×	**	**	×	-	***	×	×	×	×	×	×	**	×	×	×	×	×	***	×	**	**	×	**	***	**	×	×	×	×	×	×	×	***
7	×	×	×	*	×	×	-	*	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	**	**	**	×	×	×	×	×	**	×	**
8	***	***	***	×	×	**	***	-	**	*	×	***	**	***	×	**	*	×	***	***	×	×	*	×	**	***	***	×	**	*	***	**	*	**	***
9	×	*	×	×	×	×	×	*	-	×	***	×	×	×	×	*	×	**	*	×	*	**	×	×	×	×	×	×	*	×	×	**	×	**	**
10	×	×	×	×	×	×	×	*	×	-	***	**	*	*	×	×	**	×	×	×	*	×	×	×	×	×	×	×	×	×	×	×	×	×	**
11	×	*	×	×	**	*	×	×	**	***	-	**	***	×	**	**	**	**	×	**	***	×	**	×	**	**	**	×	**	***	***	×	**	***	*
12	×	**	×	×	×	**	×	×	*	×	*	-	**	×	×	×	***	×	×	*	×	×	×	***	×	×	***	×	*	×	**	×	*	×	**
13	**	×	×	×	×	×	×	×	×	×	×	**	-	×	×	×	×	×	×	×	***	×	**	×	**	*	***	×	×	*	×	×	***	×	×
14	×	×	×	*	×	×	**	×	×	×	×	×	×	-	×	×	×	*	×	×	×	×	×	×	*	×	×	×	×	×	×	×	×	×	**
15	×	×	×	×	×	×	×	×	×	×	×	***	***	*	-	×	×	×	×	×	***	×	**	×	×	***	***	×	×	***	×	×	×	×	**
16	***	×	×	*	*	**	×	***	×	×	**	×	**	×	*	-	×	×	***	×	**	×	×	×	×	**	×	×	×	×	×	**	*	×	**

17	×	×	×	×	×	×	×	×	×	*	×	×	***	×	***	×	-	×	×	**	×	×	×	×	×	×	***	×	×	×	×	×	*	×	***
18	×	×	×	×	**	×	×	×	×	×	×	×	**	×	×	×	×	-	×	*	×	×	×	×	×	×	**	×	**	***	×	×	×	***	**
19	**	×	×	**	***	***	*	×	*	**	***	×	**	**	***	×	×	*	-	**	×	***	**	***	×	×	***	×	×	***	***	***	*	×	**
20	×	×	×	×	×	×	×	***	×	×	**	×	**	×	*	×	×	×	**	-	***	×	×	×	×	×	***	×	×	×	×	×	**	×	×
21	×	*	×	×	×	×	×	×	×	×	*	×	**	×	*	**	**	*	×	**	-	***	**	**	×	×	**	×	**	×	×	×	×	**	×
22	×	×	×	×	*	×	*	×	×	×	×	×	***	×	*	×	×	×	**	×	×	-	***	**	×	×	**	*	×	***	×	×	×	×	**
23	×	×	×	×	*	×	×	×	×	*	*	×	**	×	***	×	×	×	*	×	×	*	-	**	×	×	***	**	×	*	×	×	***	×	×
24	×	×	×	**	*	×	×	×	×	×	**	*	**	*	***	×	*	×	*	×	×	×	×	-	×	×	**	***	×	**	×	*	*	×	*
25	***	*	***	***	**	***	***	***	***	***	***	***	***	×	**	***	**	***	***	***	**	×	**	×	-	***	***	**	***	**	***	***	***	×	***
26	***	*	*	*	**	***	*	**	*	***	×	×	×	×	×	*	×	×	***	*	×	**	×	×	×	-	*	×	**	**	**	×	**	×	**
27	×	×	×	×	×	×	×	×	×	×	×	×	**	×	*	×	×	×	×	×	**	×	×	×	×	×	-	×	×	×	×	×	×	×	×
28	×	×	×	**	**	*	**	×	×	×	×	***	*	**	***	×	***	×	*	**	*	×	×	*	×	×	***	-	×	**	**	*	×	×	***
29	*	×	***	***	**	×	***	***	**	×	**	**	×	×	**	×	×	**	**	×	**	×	×	×	*	×	*	×	-	×	**	**	***	×	×
30	×	×	×	×	×	×	×	×	×	×	×	×	×	***	*	×	×	×	×	×	×	×	×	×	×	×	***	×	×	-	**	×	×	×	×
31	**	×	×	×	×	*	×	**	***	***	*	**	***	×	**	×	**	×	**	×	**	**	×	×	×	×	*	×	×	*	-	×	***	**	**
32	×	×	×	**	×	*	***	*	*	*	×	**	***	**	×	×	×	**	×	**	×	×	×	×	**	*	***	×	×	***	×	-	*	×	***
33	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	**	×	×	×	**	×	×	×	×	×	×	×	×	×	×	×	-	**	*
3	×	×	×	**	×	×	**	**	**	*	×	×	×	*	*	×	×	×	*	×	*	×	×	×	*	×	**	*	×	×	×	**	**	-	×

4								*																*		*								
35	×	×	×	×	×	×	×	***	*	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	**	×	×	*	×	-

Notes:
1) Pairwise Granger Causality Tests take 2 lags.
2) The null hypothesis is ‘the city in the row does not cause the cities in the column’.
3) ***, **, and * indicate significance at 1%, 5%, and 10% level respectively, which means ***, ** and * reject the null hypothesis at 1%, 5%, and 10% level respectively.

Chapter 5—Housing and Life Satisfaction in Urban China

5.1 Introduction

Housing is considered to be one of the basic requirements for daily living and the single biggest cost factor for most individuals and households. As Florida *et al.* (2013) claimed, people might expect to be happier in places where housing is more available, less expensive and more affordable. This chapter is going to examine how housing conditions affect people's life satisfaction[77] in urban China, especially how housing conditions affect housing satisfaction and overall happiness. The existing literature on subjective wellbeing in China is thin and mainly focuses on the determinants of general happiness rather than the effects of specific housing conditions.

This chapter will use the 2006 Chinese General Social Survey data and most common method of 'Ordered Probit Model' to estimate the effects of housing determinants on individual subjective wellbeing. Three models are included: the first one tests the effects of these determinants of people's housing satisfaction; the second one is to estimate the effects of these determinants on householders' overall happiness; and the last model explains the individual overall happiness based on the same independent variables, but including the housing satisfaction measures as explanatory variables as well.

The robustness checks are employed, by dropping some factors with high correlation coefficients and transforming the ordered choice dependent variable into a 0-1 binary variable. In order to test the different effects of housing conditions on different groups of people, we will divide the full sample into two groups by age (young/old) and income (rich/poor). The Chow test will be used to detect the significance of our divisions by age and income. Furthermore, both separate and interaction effects of age groups and income groups will be estimated by dummy variables in the overall regression.

Additionally, housing satisfaction may be correlated with the error term in the life satisfaction equation, because some people may be more easily 'satisfied' with both their life and their house. Thus, a Ramsey RESET procedure is applied to rescue the latent problem of misspecification by using the predicted value of housing satisfaction in the overall happiness function. Another original innovation is to add the money equivalent effects of housing

[77] The terms 'happiness', 'life satisfaction' and 'subjective wellbeing (SWB)' are used interchangeably in this chapter.

conditions on overall happiness, where we will concentrate on the impact of one more square meter of a house on life satisfaction controlling for a certain level of annual income.

Our findings reveal that the housing characteristics affect different groups of people differently. Generally speaking, the housing-related conditions impact individual's housing satisfaction more directly and significantly than overall life satisfaction. But the individual features affect people's general happiness more significantly than housing satisfaction. Meanwhile, the housing satisfaction has played an important role in general happiness. The money equivalent analysis supports the view that the poorer the householders, the easier it is to increase their happiness.

There are six sections in this chapter: the first two are the 'Introduction' and the 'Literature Review' as usual; the third part on 'Data Sources and Date Description' describes the questionnaires of the survey and the primary statistics of the dataset; the following section is 'Methodology', which explains the various estimations and tests; the 'Empirical Results' part comprehensively exhibits our innovative findings; the last section is the 'Conclusion' to summarise this chapter.

5.2 Literature Review

The empirical studies on the all-pervasive determinants of subjective well-being/life satisfaction/happiness have experienced a worldwide increase over recent years, such as Oswald (1997) and Guven & Sorensen (2012) on the United States; Ferrer-i-Carbonell and Gowdy (2007) on the United Kingdom; Saris (2001) on Russia; Abbott & Sapsford (2006) on post-Soviet Russia and Ukraine; Cattaneo *et al.* (2009) on Mexico; Ambrey & Fleming (2013) on Australia; Posel & Casale (2011) on South Africa; Borooah (2006) on Northern Ireland; Camfield *et al*. (2009) and Zanuzdana *et al*. (2013) on Bangladesh; Cunado & Gracia (2012 & 2013) on Spain; Frey & Stutzer (2000) and Kahlmeier *et al.* (2001) on Switzerland; Groot & Van Den Brink (2002) on Netherlands; Oswald *et al.* (2003), Dittmann & Goebel (2010), and Nakazato *et al.* (2011) on Germany; Dumludag (2012) on Turkey; Noor *et al.* (2012) on Malaysia; Gray *et al.* (2013) on Thailand; Elsinga & Hoekstra (2005), Diaz-Serrano (2009), and Jagodzinski (2010) on Asia and Europe.

Table 5.1: Literature on Different Categories of Determinants of Life Satisfaction

Determinants	Literaures
Economic factors (income, relative income, GDP, savings, debt, employment and so on)	Oswald (1997) on US, Abbott and Sapsford (2006) on post-soviet Russia and Ukraine, Camfield *et al.* (2009) on Bangladesh, Jagodzinski (2010) on Asia and Europe, Posel and Casale (2011) on South Africa, Dumludag (2012) on Turkey, Guven and Sorensen (2012) on US, Noor *et al.* (2012) on Malaysia
Demographic factors (age, gender, education, marital status, health and so on)	Oswald (1997) on US, Groot and Van Den Brink (2002) on Netherlands, Abbott and Sapsford (2006) on post-soviet Russia and Ukraine, Borooah (2006) on Northern Ireland, Cunado and Gracia (2012) on Spain, Zanuzdana *et al.* (2013) on Bangladesh, Ambrey and Fleming (2013) on Australia.
Social Factors (social class, family or non-family relations, institutional trust, democracy factors and so on)	Frey and Stutzer (2000) on Switzerland, Hudson (2006) on European countries, Guven and Sorensen (2012) on US, Noor *et al.* (2012) on Malaysia, Gray *et al.* (2013) on Thailand
Cultural and religious factors	Jagodzinski (2010) on Asia and Europe, Noor *et al.* (2012) on Malaysia
Environmental factors (environment, neighborhood and so on)	Ferrer-i-Carbonell and Gowdy (2007) on UK, Dittmann and Goebel (2010) on Germany, Cunado and Gracia (2013) on Spain
Housing related factors (housing conditions, housing qualities, homeownership and so on)	Kahlmeier *et al.* (2001) on Switzerland, Oswald *et al.* (2003) and Nakazato *et al.* (2011) on Germany, Elsinga & Hoekstra (2005) and Diaz-Serrano (2009) on Europe, Cattaneo *et al.* (2009) on Mexico, Clapham (2010)

This literature has paid attention to different aspects of factors associated with life satisfaction. According to the review on the factors affecting subjective well-being by Dolan *et al.* (2008), Table 5.1 presents several major categories of determinants commonly studied by previous scholars. More specifically, there are some studies presented focusing on the housing related factors of life satisfaction. For example, Kahlmeier *et al.* (2001) use the example of the north western region of Switzerland to indicate that an improvement in the perceived housing environmental quality significantly contributes to an increase in subjective well-being; Oswald *et al.* (2003) states housing/life conditions play an important role for elderly people in two rural regions of Germany; Elsinga & Hoekstra (2005) and Diaz-Serrano (2009) demonstrate the effects of homeownership on life satisfaction particularly on housing satisfaction; Cattaneo *et al.* (2009) specifically elaborate on the negative impact of dirty floors on child health and adult happiness; Clapham (2010) suggests the importance of housing policy in improving the self-esteem and positive identity of residents; Nakazato *et al.* (2011) illustrate the influence of changes in living conditions on subjective well-being in Germany.

Because the empirical studies on life satisfaction adopt large survey data in terms of ordered responses to questions on well-being to estimate the regression, even though they have different target determinants associated with subjective well-being, the most common model is an Ordered Probit Regression (Dolan *et al.*, 2008). The general form is: $SWB_{report} = r(h)$, where the self-reported SWB, often a response to a single life satisfaction or overall happiness question, is some reporting function *(r)* of the true SWB *(h)*, and the true SWB is determined by a range of social, economic and environmental factors *(X's)*. This is usually modelled empirically as an additive function:

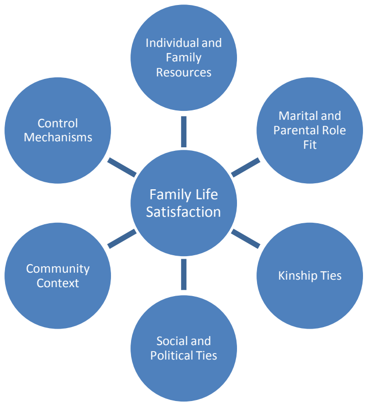
$$SWB_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \varepsilon_{it} \tag{5.1}$$

where individual differences in reporting are captured within the error term.

Although there is now a large literature on the linkages between housing and happiness, most studies have focused on developed countries. The literature on subjective well-being in China is rather thin. Contemporary China is an interesting case study for this topic, since it has experienced rapid and sustained economic growth for the last three decades, as has the Chinese housing market. Housing is an item on which Chinese people spend a great deal of thought, effort, and financial resources due to the long tradition of preferring to live and work in peace and contentment ('*An Ju Le Ye*' in Chinese). In recent years, there has been a rising concern over the issue of life satisfaction in China (Ji, Xu, and Rich, 2002; Fleischer, 2007; Knight and Gunatilaka, 2010 & 2011; Appleton and Song, 2008; Smyth *et al.*, 2008 & 2010; Knight *et al*., 2009; Nielsen *et al*., 2010; Shek, 2010 & 2011; Chyi and Mao, 2012; Davey and Rato, 2011; Wang and VanderWeele, 2011; and Hu, 2013). However, only very few studies partially include or focus on the relationship between housing and happiness (Knight and Gunatilaka (2010 & 2011), Knight *et al.* (2009) include the comparable variable of 'living standards'; Chyi and Mao (2012) use 'number of rooms' as one of the explanatory variables; Hu (2013) pays attention to homeownership).

Ji, Xu and Rich (2002) use as their sample the 1993 China Housing Survey in Shanghai and Tianjin to explore the determinants of family life satisfaction among married people in urban China. They draw the following connected network to forecast the factors affecting family happiness (Figure 5.1). While in each section of the determinants, they include more specific explanatory variables as shown in Table 5.2. Take the section of 'Individual and Family Resources' for example, the factors include health status, family income, satisfaction with family income, respondent's education, respondent employed, respondent's spouse employed, and satisfaction with job.

They use a general OLS regression model: $Y = \beta X + \varepsilon$, where Y is a vector of observations on the dependent variable, family life satisfaction; X is a matrix containing observations on the independent variables; β is a vector of regression coefficients; and ε is an error vector. They find that the family relationship, such as co-residence and frequent contact with parents, and satisfaction with relative relations, is a significant determinant of family life satisfaction, indicating Chinese filial norms that favor the family over individualism. Additionally, the formal and informal ties are important for predicating family life satisfaction in urban China, such as respondents linked with the Party, colleagues, supervisors, and especially unit managers.



(Source: Ji, Xu and Rich, 2002, Figure 1, p.171)

Figure 5.1: Predicting Family Life Satisfaction in Reforming Urban China: An Integrated Model

Table 5.2: Independent Variables of the Predicating Family Life Satisfaction Model

Individual and Family Resources	**Marital and Parental Role Fit**	**Kinship Ties**	**Social and Political Ties**	**Community Context**	**Control Mechanisms**
Health status	Satisfaction with marital sex	Parental contacts (index)	Closeness with supervisor (index)	Community conditions (index)	City
Family income	Husband's participation in chores (index)	Sibling contacts (index)	Relationship with unit leader	Community services (index)	Gender
Satisfaction with family income	Wife's participation in chores (index)	Nuclear family	Respondent party identification	Satisfaction with community	Age
Respondent's education	Satisfaction with	Satisfaction with	Spouse party identification	-	-

	household chores	relative relations			
Respondent employed	Number of children	-	Satisfaction with colleagues	-	-
Respondent's spouse employed	Satisfaction with children	-	Satisfaction with supervisor	-	-
Satisfaction with job (index)	-	-	-	-	-

Source: Ji, Xu and Rich (2002)

Knight and Gunatilaka (2010), and Knight *et al.* (2009) use the 2002 Chinese Household Income Project (CHIP) data to comprehensively estimate the determinants of subjective well-being of rural-urban migrants and the rural population in China respectively. In 2011, Knight and Gunatilaka further studied the effects of economic growth on happiness in China using the same household survey. Their basic models are of the form

$$W_i = \alpha + \beta X_i + \varepsilon_i \tag{5.2}$$

where W_i is a cardinal measure of happiness and X_i is a vector of explanatory variables, or of the form

$$W_i^* = \alpha + \beta X_i + \varepsilon_i \tag{5.3}$$

where W_i^* is a latent variable and what is observed are different categories of an ordered categorical variable. Equation 6.2 is estimated by OLS and Equation 6.3 uses an ordered probit estimator. However, in line with the methodological analysis by Ferrer-i-Carbonell and Frijters (2004), no substantive differences were found between the results using the two estimations. Table 5.3 summarises the explanatory variables involved and findings of their work respectively. It can be seen that they not only use the same database but also adopt the same common models—OLS estimation and Ordered Probit estimation—involving the study of life satisfaction. However, for different target population groups, they select relatively distinct explanatory variables. For instance, for the group of rural-urban migrants, Knight and Gunatilaka (2010) use some harshness of city life variables, such as number of relatives and friends in city, child still in village, urban living happier, house area per capita, living in own house and so on; for the group of rural population, Knight *et al.* (2009) select some community and attitudinal variables, such as number of phones, satisfaction with clinic, hilly or mountainous terrain, degree of harmony among lineages or in village and so on; for the group of urban people, Knight and Gunatilaka (2011) adopt some insecurity variables, such as unemployed, corruption, social polarization, immorality, and so on.

Although the above scholars (Knight and Gunatilaka, 2010 & 2011; Knight *et al.*, 2009) investigate the determinants of happiness for rural-urban migrants, rural population and urban citizens in China respectively, they get some identical conclusions on some demographic factors: generally speaking, the age has a significant negative effect on individual’s happiness but the square of age has a positive effect; female is happier than male; married people are happier than divorced and widowed population; the good health status and income positively affect subjective well-being; also, the unemployment status makes people less satisfied with overall life.

Appleton and Song (2008) also use the 2002 CHIP dataset to explore the components and determinants of life satisfaction in urban China including unemployment, income, marriage, sex, health and age; inter alia, focusing on the influence of social networks, Communist Party membership and political participation. They suggest that economic growth and low inflation contributed to people’s overall happiness. Political roles significantly raise life satisfaction as well. Generally, people are dissatisfied with over pollution, but this—like job insecurity—does not appear to have a direct impact on life satisfaction in urban China. Of course, it may have indirect effects via health.

However, Smyth *et al.* (2008) use the 2003 China Mainland Marketing Research Company (CMMRC) survey in 30 Chinese cities to further analyse the linkage between the environment and subjective well-being in urban China and they draw the conclusions, that citizens in urban China report significantly lower levels of satisfaction ceteris paribus with high levels of atmospheric pollution, environmental disasters and traffic congestion, while people show a significantly higher level of subjective well-being ceteris paribus with greater access to parkland.

Later, Smyth *et al.* (2010) and Nielsen *et al.* (2010) adopt the Personal Well-being Index (PWI) to ascertain the happiness of the urban population and off-farm migrants in China respectively. Both papers illustrate the statistical relationship between gender, age, income and well-being through the methods of item-total correlations, domain inter-correlations, factor analysis for the PWI items and the regression on personal domains.

Recently, Shek (2010, 2011) introduces the background knowledge of quality of life (QOL) of Chinese people in a changing world and employ a new survey—'Chinese General Social Survey (CGSS)', which is broadly used by later researchers on the study of life satisfaction in China. Wang and VanderWeele (2011), Chyi and Mao (2012), and Hu (2013) use the 2003, 2005 and 2006 CGSS survey datasets to explore the determinants of happiness in different Chinese population groups.

Wang and VanderWeele (2011) investigate the factors that related to the subjective well-being of Chinese urban residents including both common demographic variables (such as gender, income, marital status, employment, education, party membership) and some inventive factors—fashionable consumption and relative deprivation. They find that there is a U-shaped relationship with age; also, the married status, the higher income and the employment significantly increase individual's happiness; however, the effect of education is not significant.

Chyi and Mao (2012) examine the determinants of happiness of the Chinese elderly and particularly pay attention to whether living with their children and whether living with their grandchildren affects the happiness of the elderly. Their findings suggest the good health and living with grandchildren play an important role in elder's life satisfaction; while living with the children makes old people less happy. More interestingly, people feel happier with the increase of age among the elder population.

Hu (2013) explores the effect of homeownership status on individual subjective well-being indicators in urban China, which is the first time the relationship between homeownership and life satisfaction has been investigated in the setting of China. Hu's work indicates the negative effect of age and the positive effect of the age's square. In addition, he shows that the female gender, the married status, the higher income, the higher education and the better health status significantly increase urban citizens' overall happiness. More importantly, there is strong evidence of the determinant of homeownership playing a crucial role in subjective well-being. Table 5.4 summarises the above recent work on Chinese happiness and exhibits their methodologies and hypothesised factors.

To sum up, according to the existing literature on Chinese happiness studies, most researches include the common basic demographic factors of happiness, such as age, gender, marital status, health, education, income, employment. In order to discuss the subjective well-being of different Chinese groups, scholars focus on distinct comparable determinants. The prevalent models used in the issue of life satisfaction are either OLS regressions or Ordered Probit regressions; in particular instances, instrumental variables are used to address an endogeneity problem (Knight and Gunatilaka, 2010 and 2011; Chyi and Mao, 2012).

Table 5.3: The Methodologies and Findings of Knight and Gunatilaka (2010, 2011) and Knight *et al.* (2009)'s Works

	Knight and Gunatilaka (2010)	**Knight *et al.* (2009)**	**Knight and Gunatilaka (2011)**		
Title of the paper	Great Expectations? The Subjective Well Being of Rural-Urban Migrants in China	Subjective Well-being and its Determinants in Rural China	Does Economic Growth Raise Happiness in China?		
Models	OLS, Probit, Ordered Probit and Instrumented Probit estimations				
Data	The 2002 CHIP survey data				
Dependent variable	Rural-urban migrants' happiness	Happiness in rural China	Happiness in rural China	Happiness in urban China	Happiness of rural-urban migrants
Explanatory variables	***Basic variables***: Male Married Male and married In good health Education (years) Unemployed Duration of urban residence (years) Duration of urban residence, squared ***Conventional economic variables***: Log of per capita household income 2002 Net financial assets Working hours ***Comparison variables***: Expect big increase in income over next 5 years Expect small increase in income over next 5 years Expect decrease in income over next 5 years Log of average per capita urban income in city of current residence Log of average rural income in province of origin ***Harshness of city life variables***:	***Basic variables***: Age Age squared Male (sex) Married Divorced Widowed Ethnic minority dummy Education (years) Unemployed In good health In a good mood ***Absolute income variables***: Log of per capita household income 2002 Net financial assets Working hours ***Comparison variables***: Lived outside township for at least a year Household income much above village average Household income above village average Household income below village average Household income much below village average Current living standards better than 5 years ago Current living standards worse than 5 years ago Expect big increase in income over next 5 years Expect small increase in income over next 5 years	Use the same explanatory variables with Knight *et al.* (2009) **excluding** ethnic minority dummy, education (years), unemployed, in a good mood, lived outside township for at least a year, and community variables.	***Basic variables***: Age Age squared Male Married Divorced Widowed In good health ***Conventional economic variables***: Log of per capita household income Net wealth Working hours ***Comparison variables***: Extent of fairness, income distribution in China Extent of fairness, income distribution in city Living standard in second highest quarter in city Living standard in third highest quarter in city Living standard in lowest quarter in city Expect big increase in income	Use the same explanatory variables with Knight and Gunatilaka (2010) **excluding** education (years), unemployed, urban living happier, house area per capita, living in own house, permanent or long-term contract work, and temporary work.

	Living with family members Number of relatives and friends in city Child still in village No heating Urban living happier House area per capita Living in own house Permanent or long-term contract work Temporary work Satisfaction with job Index of discrimination Can find another job in 2 weeks Can find another job in 1 month Can find another job in 2 months Can find another job in 6 months Need more than 6 months to find another job	Expect decrease in income over next five years Gini Coefficient at county level ***Community variables***: Phone Satisfaction with clinic Extent to which spokesman represents interests Total village population at end 2002 Hilly terrain Mountainous terrain ***Attitudinal variables***: Degree of harmony among lineages Degree of harmony in village Agree that money is important Importance of family Importance of friends Importance of religion	over next 5 years Expect small increase in income over next 5 years Expect decrease in income over next 5 years Ln average per capita income in province ***Insecurity variables***: Unemployed Corruption is most important social problem Unemployment or laid-off work most important problem Social polarization is most important social problem Immorality is most important social problem Enterprise made high profit Enterprise made loss Laid off work some time in 2002
Findings	They make three basic hypotheses: migrants had false expectations about their future urban conditions, or about their future urban aspirations, or about their future selves. Their findings imply that certain features of migrant conditions make for unhappiness, and that their high aspirations in relation to achievement, influenced by reference groups, also make for unhappiness.	Rural China is not a breeding ground of life dissatisfaction. Subjective well-being is influenced by relative income within the village and relative income over time, both in the past and expected in the future. Although the poverty of rural China, social functioning, attitudes and expectations are important to happiness, income and various proxies for 'capabilities' and 'functioning' appear as arguments.	They emphasise the importance of relative income, rising urban insecurity, rapid urbanization, and changing reference groups in preventing happiness from rising with income.

Table 5.4: The Summary of Recent Happiness Studies in China

	Wang and VanderWeele (2011)	Chyi and Mao (2012)	Hu (2013)
Title of the paper	Empirical Research on Factors Related to the Subjective Well-Being of Chinese Urban Residents	The Determinants of Happiness of China's Elderly Population	Homeownership and Subjective Wellbeing in Urban China: Does Owning a House Make You Happier?
Data	The 2003 CGSS survey	The 2005 CGSS survey	The 2006 CGSS survey
Dependent variable	The subjective well-being of Chinese urban residents	Happiness of China's elderly population	Housing satisfaction and overall happiness in urban China
Explanatory variables	Demographic factors (gender, age, marital status, employment, party membership, income and education) Fashionable consumption Relative deprivation (social comparison) Work units Regional division	Lives with children Lives with grandchildren ln(family income) Owns estate Number of rooms Widowed Age Education Good health So-so health Bad health Communist ***Instruments***: Age of eldest child Number of children	Homeownership ***Individual characteristics***: Age Age squared Female Marital status Education Self-rated health Job status ***Household characteristics***: Household size Log of household income ***House-related characteristics***: Number of rooms Have a living room Have a bathroom House type
Models	The complementary log-log link regression model (McCullagh and Nelder, 1989; Long, 1997): $link[\gamma_j(x)] = \theta_j - \beta^T X = \theta_j - [\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_m X_m]$ where here 'link is chosen as complementary log–log and $\gamma_j(x)$ is the cumulative probability of the for '*j*th' category with covariate values *x* i.e. the probability of being in category *j* or less, θ_j is the threshold of the '*j*th' category; $X_1 - X_m$ are the independent variable of and $\beta_1 - \beta_m$ are the	OLS estimation with instrument variables (the number of alive children of an elderly person, the age of the elderly person's eldest child and its squared term)	The ordered probit model to quantify the effect of homeownership status on individual subjective well-being: $y = \beta_1 * HO + \beta_2 * X + \varepsilon$ where *y* denotes individual housing satisfaction or overall happiness, *HO* is the key explanatory variables of interest, indication whether one is a home owner or not. The

	regression coefficients of these variables. The log–log link is used so as to avoid issues of misinterpretation of odds ratios which arise with common outcomes; qualitative conclusions, however, are similar irrespective of how the outcome is modeled. Coefficients for the model are exponentiated to obtain percentage increases in the log probability of higher SWB.		vector X includes the three categories of variables: individual characteristics, household characteristics and house-related features.
Conclusion	Higher happiness can be predicted by factors of female gender, high-income class, marriage, employment, fashionable consumption, less sense of relative deprivation, and party membership. Inter alia, the sense of relative deprivation has the strongest explanatory power. This suggests that the most direct threat to current subjective well-being in urban China is that its residents are living in a society with dramatic change, competition and increasing inequalities.	They suggest that, conditional on living with a grandchild, living with one's child has a negative effect on the elderly's happiness. Furthermore, elderly Chinese who live with grandchildren are associated with a much higher degree of happiness than their counterparts.	Their results suggest that the homeownership status does have a strong positive effect on both one's housing satisfaction and overall happiness in urban China. The homeownership status might also contribute to other possible aspects of life satisfaction except for housing satisfaction; because controlling for housing satisfaction in the equation, the homeownership status still positively affects one's overall happiness. Additionally, in terms of housing satisfaction, females seem to value much more on owning a house than males, while the subjective benefits of owing a house in large cities seem to be much smaller than in small cities.

5.3 Data Sources and Data Description

This chapter uses the dataset from the 2006 Chinese General Social Survey (the 2006 CGSS)[78], a nationwide comprehensive characteristic social survey exploring the current life situations of China's citizens. The 2006 wave of the CGSS survey applies the four-phase stratified sampling approach to identify the sampled households: county (district), town (street), village (neighbourhood committee), and household. The interviewees, who have stayed or will stay in the household for more than one week, are selected stochastically among members aged between 18 and 69. It contains a total of 6013 urban households in 28 provinces, municipalities, and autonomous regions of China[79].

The 2006 CGSS urban household questionnaire includes plentiful material on personal characteristics of household members, especially the respondents, such as their gender, age, ethnic group, education, religion and employment. Of course, the survey contains general household features as well, such as marital status, family size, income, social activities and living standards. Impressively, the project also draws a general image of the current housing situation in urban China by asking the interviewees about their housing conditions, which can contribute to our research on the Chinese urban housing market. This category of housing questions involves the homeownership status (for example, whether the individual rents the house or owns the house), the housing conditions (for instance, structure/usable areas of the house, number of bedrooms, whether they have a living room or a bathroom), and the housing type (shanty town, affordable housing, commodity housing, housing units purchased by individuals from their work units, and other types of houses).

In the self-evaluation section about the individual's life satisfaction, two subjective wellbeing indicators of interest, housing satisfaction and overall happiness, are analysed. Personal housing satisfaction is documented as the following question and options: '*Are you satisfied with your current housing situation? (1) very unsatisfied (2) unsatisfied (3) satisfied (4) very satisfied (5) unknown*'. The individual overall happiness assessment is based on a 5-point ranking system which is '*(1) very unhappy (2) unhappy (3) neutral (4) happy (5) very happy*'. In summary, Table 5.5 outlines the original questionnaire responses used as variables in our

[78] CGSS 2006 is conducted cooperatively by the Sociology Department of Renmin University of China and the Survey Research Centre of Hong Kong University of Science and Technology in September and October, 2006.

[79] There are totally 31 provinces in mainland China. The three missing provinces in the survey are Qinghai, Ningxia and Tibet. The omission of these 3 provinces would not affect the nationwide representativeness of the survey, as the population in these regions only accounts for a very small proportion of the whole nation.

study.

Excluding the missing and invalid answers of the questionnaire dataset, in order to investigate the preliminary statistical relationship between these variables, Table 5.6 shows the correlation coefficients between subjective wellbeing variables (housing satisfaction *qe485* and overall happiness *qe49*) and other explanatory variables. Regarding people's housing satisfaction, we can see that self-rated health, homeownership, house size and number of bedrooms have quite high correlations (coefficients>20%); having living rooms and having bathrooms have relatively high correlation (10%<coefficients<20%); while other variables have very small coefficients. Regarding overall happiness, only housing satisfaction has a high correlation with overall happiness more than 20%, and the correlations of all house-related variables have been reduced. But the correlations of individual variables become stronger. Moreover, there exist extremely high correlations between certain explanatory variables, for instance, between age and job status (53.53%), house size and number of bedrooms (65.23%), number of living rooms and number of bathrooms (53.48%). Therefore, one of the robustness checks that can be employed is by dropping one of these two highly correlated variables (such as job status, number of bedrooms and number of bathrooms) to compare with the original regressions.

To explore the further relationship between these factors and an individual's life satisfaction, Table 5.7 reviews the statistical features of the relevant variables. We are particularly interested in the responses of different groups. As young people and old people probably have different perspectives about housing, this chapter divides the urban sample into two groups divided by the age boundary of 42 resulting in 2202 'young people' and 2242 'old people'. According to the literature (Chen and Short, 2008; Chyi and Mao, 2012), the living arrangements, such as whether living with family (spouse, children or grandchildren), have an important effect on the happiness of senior citizens in China. This may be because the traditional culture of happiness for elderly people in China is being able to 'play with children and grandchildren, enjoy life with no worries'. Therefore, older people may typically spend more time in the house than younger ones, at least in some localities, and hence for older people housing conditions may be more important than for younger ones.

In addition, the householder income is quite important for the housing purchase; because with higher income, individuals can most likely afford higher-standard houses with larger space, lots of rooms, convenient location, or high-grade commercial housing. Income also facilitates the purchase of durable and other goods and services which can enhance the quality of the home. Also, plenty of studies (Knight and Gunatilaka, 2010 & 2011; Appleton and Song, 2008; Smyth *et al.*, 2008; Knight *et al.*, 2009; Chyi and Mao, 2012; Wang and VanderWeele, 2011; and Hu, 2013) support that the income plays an important role in an individual's subjective well-being in China. Thus, an additional category is in terms of householder income with approximate size by the annual income boundary of 10000 (2386 low-income households and 2056 high-income households). As above literature suggest, generally speaking, the income significantly affects people's happiness in a positive way, which means people feel happier with higher income.

From Table 5.7, it can be seen that most people (53.15%) are either satisfied (45.61%) or very satisfied (7.54%) with their general housing situation. From now on, we refer to this group as 'being at least satisfied'. While there are more old people (55.67%) satisfied or very satisfied with their housing than young people (50.59%); and people with higher income (56.15%) have significantly higher housing satisfaction ('being at least satisfied') than low-income individuals (50.88%), this is as expected because high-income citizens can afford better houses and the Tiebout hypothesis suggests that as people age they move to locations and by implication houses which they find more favourable. For the overall happiness, the statistics indicate that there are conspicuous differences between the young population (51.68%) and old population (43.48%) and between the low-income group (40.49%) and high-income group (55.74%), who are happy or very happy about their lives.

From Table 5.7, we can also see that the homeownership rate in urban China is 74.11%, which is relatively high compared to developed countries, reflecting the traditional belief of Chinese people preferring owning houses to renting houses (Chien, 2010; Wang, 2011). Besides, under the marketization and commercialization of the Chinese housing market, the welfare housing system has become less important; and most people need to purchase commodity houses from the housing market, only a few middle- or low-income individuals can purchase or rent affordable houses from the government. Therefore, the portion of commercial houses is significantly larger than the portion of affordable houses in all the groups of people. Of course, younger people (26.52%) own more commercial houses[80] than

[80] In the 2006 CGSS categories, 'commercial houses' include two types of houses: ordinary commodity house and high-grade commercial house or villa house.

elder (21.47%), as they probably need to buy commodity houses over recent years but elder people might have purchased their welfare houses before the housing reform. It is also reasonable for rich people (30.06%) to own more commercial houses than poor people (18.73%). With respect to other housing conditions, 81.47% of houses have living rooms and 83.16% of houses have bathrooms; furthermore, the younger or richer groups of people have higher percentages of living rooms/bathrooms than the older or poorer groups of people. This maybe because the younger people purchased relatively newer houses than their elders, and rich people are able to afford higher-standard houses as well.

In order to do a preliminary investigation of the effects of housing conditions on people's housing satisfaction or overall happiness, we present separate tables for the determinants of homeownership, house type, house size, number of bedrooms and having living rooms or bathrooms (see Table 5.8). According to the statistics in

Table 5.8, there are a much higher percentage of people having homeownership and who are happier (higher percentages of satisfaction) with their housing conditions (60.79%) and overall life (51.21%) than people with no homeownership (31.30% and 37.04%). Moreover, citizens who live in commercial housing also show a little more happiness for both subjective wellbeing indicators (57.19% for housing satisfaction and 53.43% for overall happiness) than the ones who live in the lower-standard houses—economically affordable housing (52.20% and 50.89% respectively).

In addition, there is substantial evidence that the percentage of satisfied or happy people grows with the increase of the house size and number of bedrooms. For instance, individuals living in housing larger than 90 m^2 are characterised by 77.42% of housing satisfaction and 57.70% of overall happiness, but these two ratios for individuals living in housing smaller than 42 m^2 are only 25.64% and 33.67% respectively. The same situation happens among the people having 9 bedrooms; their satisfaction levels are as high as 90% and 70% respectively, while only 30.31% and 37.46% of people with 1 bedroom are satisfied with their housing and overall life. Of course, this could also reflect income or the number of people living in the house. Furthermore, more people having living rooms or bathrooms are happy with both indicators than people having no living rooms or bathrooms. More specifically, with living rooms, 56.78% or 49.24% of people are happy with their housing or overall life; while without living rooms, only 37.18% of people are satisfied with their housing and 40.10% of people are happy with overall life. People with bathrooms show higher percentages of housing satisfaction (56.77%) and overall life satisfaction (48.94%) than people without bathrooms (35.29% and 40.64% respectively) as well.

Overall, from the primary results, the housing-related variables appear to play a crucial role in the individual subjective well-being—both housing satisfaction and overall happiness. The statistical data illustrates that people are much more likely to be satisfied with both indicators of homeownership, larger house space, more bedrooms, having living rooms/bathrooms, or living in better-standard houses (such as commodity houses). In particular the difference between different housing conditions causes a distinct difference in housing satisfaction than for overall happiness, which can be explained because housing conditions affect individual housing satisfaction more directly than people's overall life. However, correlation does not imply causation and we now turn to examine causal impacts with the ordered probit model to further investigate the significance of these house-related determinants and how they affect people's subjective well-being.

Table 5.5: The 2006 CGSS Questionnaire List

Variable type	Question code	Question	Notes
Subjective wellbeing indicators	*qe485*	Housing satisfaction	1) very unsatisfied 2) unsatisfied 3) satisfied 4) very satisfied 5) unknown
	qe49	Overall happiness	1) very unhappy 2) unhappy 3) neutral 4) happy 5) very happy
Individual characteristics	*age*	Age	-
	qa01	Gender	1) male 2) female
	qd01	Marital status	1) single 2) cohabiting 3) married 4) separated 5) divorced 6) widowed
	qa05a	Education level	1) never educated 2) literacy class 3) primary school 4) junior high school 5) vocational high school 6) senior high school 7) technical secondary school 8) technical school 9) junior college (Continuing Education) 10) junior college (Regular Higher Education) 11) undergraduate college (Continuing Education) 12) undergraduate college (Regular Higher Education) 13) postgraduate or above 14) others
	qe484	Self-rated health	1) very poor 2) poor 3) good 4) very good 5) unknown
	qb01a	Job status	1) employed 2) unemployed but had a job before 3) never work
Householder characteristics	*qd35a*	Householder income (yuan)	0000000. (None) 9999997. (Inapposite) 9999998. (Unknown) 9999999. (Refuse to answer)
	qd27a	Homeownership	1) rent the house of work units 2) rent the public house 3) rent the private house 4) private house (Inheritance or self-build) 5) homeownership (part-owned) 6) homeownership (full-owned) 7) dormitory 8) living with friends or relatives 9) others
House-related characteristics	*qd28a/qd28b*	House size (m^2) (structure/usable areas)	998. (Couldn't remember) 999. (Refuse to answer) The respondents only need to answer one of the two household size questions; thus, when structure areas (qd28a) are not available, use usable areas (qd28b) instead.
	qd28c	Number of bedrooms	
	qd28d	Number of living rooms	
	qd28e	Number of bathrooms	
	qs42	House type	1) shanty town 2) the old town without development 3) community unit of industrial and mining enterprises 4) community unit of public institutions or government institutions 5) economically affordable housing 6) ordinary commodity house 7) high-grade commercial housing or villa house 8) urban village 9) immigrant communities 10) others

Table 5.6: Correlation between Subjective Wellbeing Variables and Other Explanatory Variables

	qe485	***qe49***	***age***	***qa01***	***qd01***	***qa05a***	***qe484***	***qb01a***	***qd35a***	***qd27a***	***qd28a***	***qd28c***	***qd28d***	***qd28e***	***qs42***
qe485	1.0000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
qe49	0.2998	1.0000	-	-	-	-	-	-	-	-	-	-	-	-	-
age	0.0448	-0.0979	1.0000	-	-	-	-	-	-	-	-	-	-	-	-
qa01	-0.0198	0.0152	-0.0032	1.0000	-	-	-	-	-	-	-	-	-	-	-
qd01	0.0517	0.1062	0.2865	-0.0190	1.0000	-	-	-	-	-	-	-	-	-	-
qa05a	0.0352	0.1711	-0.3643	-0.0608	-0.0862	1.0000	-	-	-	-	-	-	-	-	-
qe484	0.2412	0.2823	-0.2501	-0.0645	-0.0310	0.1609	1.0000	-	-	-	-	-	-	-	-
qb01a	0.0077	-0.0872	0.5353	0.1861	0.0432	-0.2633	-0.1877	1.0000	-	-	-	-	-	-	-
qd35a	0.0334	0.0769	-0.1403	-0.1266	-0.0571	0.2380	0.0649	-0.2261	1.0000	-	-	-	-	-	-
qd27a	0.2874	0.1308	0.1948	0.0211	0.1451	-0.0503	0.0059	0.1204	-0.0800	1.0000	-	-	-	-	-
qd28a	0.2737	0.1168	-0.0205	-0.0318	0.0801	-0.0220	0.0512	-0.0323	0.0111	0.2558	1.0000	-	-	-	-
qd28c	0.2428	0.1036	0.0347	-0.0192	0.0943	-0.0289	0.0353	-0.0145	-0.0071	0.2718	0.6523	1.0000	-	-	-
qd28d	0.1621	0.0664	-0.0383	-0.0051	0.0394	0.0548	0.0000	-0.0664	0.0536	0.1269	0.2628	0.1220	1.0000	-	-
qd28e	0.1607	0.0729	-0.0339	0.0206	-0.0005	0.1306	0.0023	-0.0657	0.1068	0.1488	0.2038	0.1171	0.5348	1.0000	-
qs42	0.0379	0.0782	-0.0855	-0.0014	-0.0563	0.1034	0.0608	-0.0834	0.1208	-0.0172	0.0280	0.0025	0.1333	0.2235	1.0000

Table 5.7: The Summary of Statistical Features of Relevant Variables

Variables		Total	By age		By income (yuan)	
			Young (<=42)	**Old (>42)**	**Low (<=10000)**	**High (>10000)**
Subjective wellbeing indicators	*Housing satisfaction (%)*					
	very unsatisfied	11.21	11.58	10.85	11.74	10.60
	unsatisfied	35.64	37.83	33.48	37.38	33.61
	satisfied	45.61	42.87	48.30	43.42	48.51
	very satisfied	7.54	7.72	7.37	7.46	7.64
	Total 'Satisfied' and 'Very Satisfied'	**53.15**	**50.59**	**55.67**	**50.88**	**56.15**
	Overall happiness (%)					
	very unhappy	0.97	0.77	1.16	1.34	0.54
	unhappy	5.67	3.95	7.37	8.21	2.72
	neutral	45.81	43.60	47.99	49.96	41.00
	happy	41.83	45.05	38.66	35.21	49.51
	very happy	5.72	6.63	4.82	5.28	6.23
	Total 'Happy' and 'Very Happy'	**47.55**	**51.68**	**43.48**	**40.49**	**55.74**
Individual characteristics	*Age (mean)*	44	32	55	45	41
	Gender (%)					
	male	48.65	49.64	47.68	39.15	59.68
	female	51.35	50.36	52.32	60.85	40.32
	Marital status (%)					
	married	80.44	72.75	87.99	80.93	79.86
	unmarried (single/cohabiting/separated/divorced/widowed)	19.56	27.25	12.01	19.07	20.14
	Education level (%)					
	low education (never educated/literacy class/primary school)	16.34	6.40	26.12	25.15	6.13
	middle education (junior high school/vocational high school/ senior high school/technical secondary school/technical school)	65.7	67.35	64.06	67.35	63.76
	high education (junior college/undergraduate college/postgraduate or above)	17.96	26.25	9.82	7.50	30.11
	Self-rated health (%)					
	very poor	2.61	1.32	3.88	3.52	1.56
	poor	19.56	12.13	26.88	23.47	15.03
	good	60.45	63.62	57.32	57.96	63.33

	very good	17.38	22.93	11.92	15.05	20.09
	Job status (%)					
	employed	59.57	82.88	36.65	45.60	75.78
	unemployed (unemployed but had a job before/never work)	40.43	17.12	63.35	54.40	24.22
Householder characteristics	*Householder income (mean)* (yuan)	14204	16745	11706	6175	23520
	Homeownership (%)					
	homeownership (private house (inheritance or self-build)/homeownership (part-owned)/ homeownership (full-owned))	74.11	67.03	81.07	76.87	70.91
	no homeownership (rent the house of work units/rent the public house/rent the private house/dormitory/ living with friends or relatives/others)	25.89	32.97	18.93	23.13	29.09
House-related characteristics	*House size (mean)* (m^2)	71.99	73.03	70.96	71.64	72.39
	Number of total rooms (mean) (the sum of bedrooms, living rooms and bathrooms)	3.86	3.87	3.84	3.80	3.92
	Number of bedrooms (mean)	2.21	2.19	2.22	2.21	2.20
	Number of living rooms (mean)	0.93	0.95	0.92	0.90	0.97
	Having living rooms (%)	81.47	83.47	79.51	79.97	83.22
	Number of bathrooms (mean)	0.89	0.90	0.87	0.82	0.96
	Having bathrooms (%)	83.16	84.65	81.70	78.33	88.76
	House type (%)					
	economically affordable housing	13.85	14.67	13.04	12.78	15.08
	commercial housing (ordinary commodity house/high-grade commercial housing or villa house)	23.98	26.52	21.47	18.73	30.06
	others (shanty town/the old town without development/urban village/immigrant communities/ community units of industrial and mining enterprises/community units of public institutions or government institutions/others)	62.17	58.81	65.49	68.48	54.86
Sample Size		4442	2202	2240	2386	2056
			4442		4442	

Table 5.8: The Descriptive Results between Individual Subjective Well-being and Housing Conditions

Variables		**Housing satisfaction (%)**					**Overall happiness (%)**					
		Very unsatisfied	Unsatisfied	Satisfied	Very Satisfied	Total	Very unhappy	Unhappy	Normal	Happy	Very happy	Total
homeownership	homeownership (74.11%)	7.17	32.05	51.49	9.30	100	0.91	4.80	43.07	44.50	6.71	100
	no homeownership (25.89%)	22.78	45.91	28.78	2.52	100	1.13	8.17	53.65	34.17	2.87	100
House type	economically affordable housing (13.85%)	13.98	33.82	48.62	3.58	100	1.14	3.09	44.88	45.69	5.20	100
	commercial housing (23.98%)	7.79	35.02	49.58	7.61	100	0.28	3.94	42.35	48.08	5.35	100
	others (62.17%)	11.91	36.28	43.41	8.40	100	1.19	6.92	47.36	38.56	5.97	100
House size (m^2)	0—42 (20.19%)	27.87	46.49	21.40	4.24	100	0.78	9.70	55.85	30.10	3.57	100
	42—57 (19.99%)	10.36	43.24	41.78	4.62	100	1.58	4.73	52.25	37.16	4.28	100
	57—69 (17.86%)	9.08	38.59	45.52	6.81	100	0.63	5.30	43.13	44.26	6.68	100
	69—90 (22.22%)	5.17	31.51	54.31	9.02	100	1.11	3.55	41.44	46.91	6.99	100
	>90 (19.74%)	3.76	18.81	64.54	12.88	100	0.68	5.25	36.37	50.63	7.07	100
Number of bedrooms	1 (19.83%)	22.81	46.88	25.77	4.54	100	0.91	8.51	53.12	34.05	3.41	100
	2 (54.50%)	10.29	36.80	45.85	7.06	100	0.95	5.12	46.92	41.14	5.87	100
	3 (19.05%)	4.85	26.12	58.75	10.28	100	0.83	4.61	39.24	47.87	7.45	100
	4 (3.42%)	3.29	23.03	61.18	12.50	100	1.97	5.92	33.55	50.66	7.89	100
	5 (0.95%)	0.00	23.81	69.05	7.14	100	2.38	2.38	50.00	42.86	2.38	100
	6 (1.04%)	2.17	15.22	69.57	13.04	100	2.17	2.17	30.43	60.87	4.35	100
	7 (0.11%)	0.00	20.00	80.00	0.00	100	0.00	0.00	20.00	60.00	20.00	100
	8 (0.43%)	0.00	15.79	68.42	15.79	100	0.00	10.53	21.05	63.16	5.26	100
	9 (0.68%)	3.33	6.67	70.00	20.00	100	0.00	3.33	26.67	63.33	6.67	100
Living rooms	having living rooms (81.47%)	8.65	34.57	49.32	7.46	100	0.80	5.31	44.65	43.60	5.64	100
	no living rooms (18.53%)	22.48	40.34	29.28	7.90	100	1.70	7.29	50.91	34.02	6.08	100
Bathrooms	having bathrooms (83.16%)	8.80	34.43	49.54	7.23	100	0.81	4.87	45.37	43.34	5.60	100
	no bathrooms (16.84%)	23.13	41.58	26.20	9.09	100	1.74	9.63	47.99	34.36	6.28	100

5.4 Methodology

According to Ferrer-i-Carbonell and Frijters (2004, pp. 643-644) on which the following is based. There are three main assumptions that have been used in the interpretation of the satisfaction questionnaire survey. Increasing in restrictiveness, these are:

"A1 General satisfaction is a positive monotonic transformation of an underlying metaphysical concept called welfare and denoted by W(.): if $GS_{it} > GS_{is}$ then $W_{it} > W_{is}$.
A2 General satisfaction is interpersonally ordinally comparable: if $GS_i > GS_j$ then $W_i > W_j$.
A3 General satisfaction is interpersonally cardinally comparable: $(W_i - W_j) = \omega(GS_i, GS_j)$ with $\omega(.)$ a function that is known up to a multiplicative constant. Normally $\omega(GS_i, GS_j)$ is taken to be (GS_i, GS_j)."

The assumption *A1* implies a correspondence between what is measured, GS_{it}, and the metaphysical concept researchers are actually interested in, W_{it}. Obviously, welfare is not a physical phenomenon that can be easily and objectively measured.

The assumption *A2*, ordinal comparability, implies that individuals share a common opinion of what happiness is. This relies on supporting evidence from two psychological findings. The first is that individuals are somewhat able to recognise and predict the satisfaction level of others. The second finding is that individuals in the same language community have a common understanding of how to translate internal feelings into a number scale.

The assumption *A3* usually amounts to assuming that the difference between a satisfaction answer of, a *3* and a *4* is the same as the difference between a *5* and a *6*.

Furthermore, Ferrer-i-Carbonell and Frijters (2004, pp. 644-645) state the statistical assumptions made, hinge on the existence and effects of unobserved factors in the data set:

"S1 There are time-varying unobserved factors, ε_{it}, related to observables in an unknown way.
S2 There are time-invariant unobserved factors, v_i, related to initial levels of observed factors, and there are time-varying unobserved factors, ε_{it}, unrelated to observed factors: $cov(\varepsilon_{it}, x_{it}) = cov(v_i, \Delta x_{it}) = 0$ and $cov(v_i, x_{it}) \neq 0$.
S3 Unobserved factors, ε_{it} or v_i, are either unrelated to observed factors or their relationship is known: $cov(\varepsilon_{it}, x_{it}) = z^1_{it}$, and $cov(v_i, x_{it}) = z^2_{it}$, with z either 0 or a known function."

The statistical assumption *S1* would seem to arise very often according to economic theory: because individuals continuously make decisions based on constraints and future expectations, anything unobserved that affects *GS* and also changes expectations or constraints will influence observed decisions. Under an *S1* situation causal inferences cannot be made.

Under *S2*, all relevant time-varying factors are thought to be observed. For instance through randomised experiments or rich data sets, all the unobserved variables appearing under *S1* are then known or exogenous.

Under *S3*, there may be unobserved factors, but they are either orthogonal to what is observed and hence do not normally bias the results, or their relation to what is observed is (due to some assumed structure) known and hence can be controlled for. This would seem to apply reasonably only in cases where the data used are extremely rich and simultaneous account can be taken of all this information.

The main model under *A2*, assuming ordinal comparability, is of a latent variable form:

$$\begin{aligned} GS_{it}^{*} &= x_{it}\beta + \varepsilon_{it} \\ GS_{it}^{*} &= k \Leftrightarrow \lambda_{k} \leq GS_{it}^{*} \leq \lambda_{k+1} \end{aligned} \tag{5.4}$$

where $\varepsilon_{it} \perp x_{it}$; GS_{it}^{*} is the latent variable and GS_{it} is observed general satisfaction. Depending on the assumed distribution of the error-term ε_{it}, this leads to an ordered probit, this can be solved by maximum likelihood methods. In order for the ensuing estimator to be causally interpreted, *S3* has to hold. Therefore *S1-S3* are still relevant, that despite the lack of a time dimension for our cross section data set. This is the model most used by economists (Dolan *et al.*, 2008; Knight and Gunatilaka, 2010 & 2011; Knight *et al.*, 2009; Hu, 2013).

Clearly, the life satisfaction indicators (housing satisfaction and overall happiness) used in this chapter are ordinal variables, we use the Ordered Probit Model to investigate the effects of various determinants on subjective wellbeing (Greene 2007, Chapter 23, pp. 831-835; Brooks 2008, Chapter 11, pp. 529-533):

$$y_{i}^{*} = \alpha + \beta_{i} X_{i} + \varepsilon \tag{5.5}$$

As usual, y_{i}^{*} is the unobservable 'true rating' (or 'an unoverved continuous varibablre ').

What we do observe is

$$
\begin{aligned}
y_i &= 0 \text{ if } y_i^* \le \mu_0 \\
y_i &= 1 \text{ if } \mu_0 \le y_i^* \le \mu_1 \\
y_i &= 2 \text{ if } \mu_1 \le y_i^* \le \mu_2 \\
&\vdots \\
y_i &= J \text{ if } J_{J-1} \le y_i^*
\end{aligned}
$$

The μ's are unknown parameters to be estimated with β. In an opinion survey, the respondents have their own intensity of feelings, which depend on certain measurable factors $\boldsymbol{X}$ and certain unobservable factors ε.

If we assume that ε is normally distributed across observations, then we have the following probabilities by normalising the mean ad variance of ε to zero and one:

$$
\begin{aligned}
&prob(y_i = 0|X) = \Phi(-X'\beta), \\
&prob(y_i = 1|X) = \Phi(\mu_1 - X'\beta) - \Phi(-X'\beta), \\
&prob(y_i = 2|X) = \Phi(\mu_2 - X'\beta) - \Phi(\mu_1 - X'\beta), \\
&\vdots \\
&prob(y_i = J|X) = 1 - \Phi(\mu_{J-1} - X'\beta).
\end{aligned}
$$

In our model, y_i^* denotes individual housing satisfaction or overall happiness. In line with the relevant literature (Appleton and Song, 2008; Chyi and Mao, 2012; Diaz-Serrano 2009; Dolan *et al.*, 2008; Elsinga and Hoekstra, 2005; Hu, 2013; Knight and Gunatilaka, 2010 & 2011; Knight *et al.*, 2009; Wang and Vander Weele 2011), the vector X includes three major categories of explanatory variables: individual characteristics (the personal information about individual householders), householder characteristics (householder's information relating to the resident housing) and house-related features (housing conditions affecting housing qualities).

The variables for individual characteristics contain age, gender (male and female), marital status (married, with 'unmarried' as default group including '*single/cohabiting/separated /divorced/widowed*'), education level (middle education including '*junior high school /vocational high school/ senior high school/technical secondary school/technical school*', high education including '*junior college/undergraduate college/postgraduate or above*', with ‘low education’ as default group including ‘*never educated/literacy class/primary school*’), self-rated health status and job status (employed, with ‘unemployed’ as default group). Because age might have a nonlinear relationship with people’s happiness, both age and age squared are included in the model. The health status is based on a 4-point measurement, ranging from ‘very poor’ to ‘very good’. It is expected that there should be a positive impact of the self-rated health status on individual subjective well-being.

Additionally, some householder-level features (such as homeownership and householder annual income) can be impact on individual happiness indicators, omitting them from the regression may lead to biased estimates of β in Equation 5.5. Therefore, this chapter includes homeownership (homeownership including ‘*private house (inheritance or self-build)/homeownership (part-owned)/ homeownership (full-owned)*’, with ‘no homeownership’ as the default group including ‘*rent the house of work units/rent the public house/rent the private house/dormitory/ living with friends or relatives/others*’), and house size (*construction areas or usable areas*, m^2) into the regression. Moreover, the analysis includes some independent variables of housing conditions, such as number of bedrooms, whether having a living room and whether having a bathroom in the current residence. These are included as Diaz-Serrano (2009) suggests that it is most likely that these variables are closely related with individual’s housing satisfaction and overall happiness, which can be indicative of the living comfort. Finally, the house types might have different effects on subjective well-being. For example, Hu (2013) finds that people living in commercial houses show a higher housing satisfaction than people staying in affordable houses. Hence, the type of house is included as one of the explanatory variables as well by dividing it into three groups: commercial housing including ‘*ordinary commodity house/high-grade commercial housing or villa house*’, other types of houses including ‘*shanty town/the old town without development/urban village/immigrant communities /community unit of industrial and mining enterprises/community unit of public institutions or government institutions/others*’, with ‘economically affordable housing’ as the default group.

Nevertheless, although we can include a much richer set of relevant housing-related determinants in the model, the estimation of happiness may still be biased. On the one side, the estimation may suffer from measurement error bias as these variables are only about individual’s current residence given the available information in the dataset. There are many other possible status/situations for these factors. On the other side, some unobserved variables (such as risk attitude or social capital) that influence the existing explanatory variables also affect their happiness, and then our model may still be biased, if these variables impact on the independent variable set which we use. Moreover, due to the restrictions of the survey, we cannot include more relevant factors of housing conditions affecting subjective well-being, such as access to gas, heating, water and so on.

The robustness checks need to be employed to test the efficiency of our model. As mentioned before, one of the robustness checks can be achieved by dropping one of the two explanatory variables with high correlation coefficients (age vs job status, house size vs number of bedrooms, having living rooms vs having bathrooms). The other robustness check we can apply is to use the 'binary response model' (Wooldridge, 2012, Chapter 17, pp.584) or 'binary choice model' (Greene, 2012, Chapter 17, pp.724). Specifically, by making our dependent variable y^* in Equation 5.5 a binary variable, wherein y_i is 1 if 'satisfied' or 'happy', y_i is 0 if 'un-satisfied' or 'un-happy'. In our case, we define that the groups of housing satisfaction with '*satisfied*' and '*very satisfied*' and the groups of overall happiness with '*happy*' and '*very happy*' as 1, while the rest of responses from housing satisfaction and overall happiness as 0.

Since we will divide the whole sample into different groups by age category and income category, it is necessary to justify the divisions of the sample by age and income. As Wooldridge (2012) suggested, the Chow test, a simply F test, can be used to determine whether a multiple regression function differs across two groups. We can apply that test to two different age groups or income groups. Thus, the Chow statistic can be computed as:

$$F = \frac{SSR_u - \left(SSR_1 + SSR_2\right)}{SSR_1 + SSR_2} \times \frac{N - 2k}{k} \tag{5.6}$$

where SSR_u is the sum of squared residuals for unrestricted model, SSR_1 and SSR_2 is the sum of squared residuals for two different groups, N is the total number of observations, and k is the total number of parameters (including dependent variable and explanatory variables). The test statistic follows the F distribution with k and $N\text{-}2k$ degrees of freedom.

As we can see, the Chow test, following the F distribution, is only used in linear regressions, which is not applicable to our ordered probit model. But, Gould (2013a) has resolved the problem by running one regression and testing whether certain coefficients are equal to zero.

According to him, the '*Chow Test is a term used by economists in the context of testing a set of regression coefficients being equal to 0, which is equivalent to pooling the data, fitting the fully interacted model, then testing the group coefficients against 0*'.

In our case, there are separate models for two groups:

$$y = \alpha_1 + \beta_{1,i} X_{1,i} + \varepsilon_1 \qquad \text{for group=1}$$

$$y = \alpha_2 + \beta_{2,i} X_{2,i} + \varepsilon_2 \qquad \text{for group=2}$$

Next, we need to generate a dummy variable D for group 2, and other dummy variables by multiplying each explanatory variables as $D_i X_i$. Then, run the following regression again:

$$y_i^* = \alpha + \beta_i X_i + \gamma D + \delta_i D_i X_i + \varepsilon \tag{5.7}$$

The last step is to test the coefficients γ and δ_i against 0 in the above pooled regression. In the case of the discrete choice model, the LR test statistics follow the Chi-square distribution. Rejecting the null means the coefficients are significantly different with 0, which indicates our age or income division is sufficient. In addition, Equation 5.7 also indicates the interactive effects between age/income dummies and other explanatory variables through testing the joint significance of coefficients δ_i.

Furthermore, in order to investigate the separate effects and interaction effects of age groups and income groups in the overall regression, we create dummy variables of the age division (D_1) and income division (D_2), as well as their interaction effects (D_3 and D_4), into Equation 5.5:

$$y_i^* = \alpha + \beta_i X_i + \sum_{j=1}^{4} \eta_j D_j + \varepsilon \tag{5.8}$$

where D_1 is 1 if age>42, and 0 if not; D_2 is 1 if income>10000, and 0 if not; D_3 is the multiplication of D_1 and income; while D_4 is the multiplication of D_2 and age. The dummies D_3 and D_4 indicate the interaction effects between age groups and income groups.

Misspecification is another latent problem for our general overall happiness function in that some people may be more easily 'satisfied' with both their life and their house. Hence housing satisfaction may be correlated with the error term in the life satisfaction equation. The Ramsey RESET (Regression Specification Error Test) test can be implemented to detect functional form problems (Greene, 2013, Chapter 5, pp.177-178; Wooldridge, 2012, Chapter 9, pp.306-307). To apply RESET, we have to decide how many functions of the fitted values to include in an expanded regression. Although there is no consensus on this issue, the squared and cubed terms have proven to be useful in most applications. Let $\hat{y}$ denotes the fitted value from Equation 5.5, the expanded equation is:

$$y_i^* = \alpha + \beta_i X_i + \delta_1 \hat{y}^2 + \delta_2 \hat{y}^3 + \varepsilon \qquad (5.9)$$

The null hypothesis is that the original equation is correctly specified. It is also equivalent to test the coefficients δ_1 and δ_2 against 0. Rejecting the null indicates that the original regression is misspecified, and the predicted value of housing satisfaction in Equation 5.9 should be used in the overall life satisfaction regression.

5.5 Empirical Results

Generally, our estimations utilise two dependent variables, namely housing satisfaction and overall happiness and three groups of explanatory variables: individual characteristics (including age, age square, gender, marital status, education level, self-rated health and job status), householder features (including log of householder annual income and homeownership), and housing-related conditions (including house size, number of bedrooms, having living rooms or bathrooms, and house type). By using the ordered probit model, three models are regressed: the first one is to test the effects of these determinants of people's housing satisfaction; the second one is to estimate the effects of these determinants on householders' overall happiness; and the last model explains the individual overall happiness based on the same independent variables, but including the housing satisfaction measures as explanatory variables as well.

5.5.1 The Effects on Housing Satisfaction

As shown in Table 5.9, the overall picture is that most of the determinants we used have quite significant effects on housing satisfaction within the full sample, except for the variables of gender, marital status, education level, and job status. As the literature suggested (Appleton and Song, 2008; Knight *et al*., 2009; Knight and Gunatilaka, 2011; Wang and VanderWeele, 2011; Hu, 2013), age is a quite significant factor for individual subjective wellbeing. In our model, there is a U-shaped relationship between age and individual housing satisfaction, as the coefficients of age and age square are -0.0327847 and 0.0004398 respectively, reaching the minimum point at approximately 37.27 $(-\frac{-0.0327847}{2*0.0004398})$[81] years. That means housing satisfaction is declining with the increase of age for the people who are younger than 37; afterwards, housing satisfaction is accelerating with the increase of age. As documented in relevant studies in China (Hu, 2013), also the health factor has a significantly positive impact on subjective housing satisfaction.

Both coefficients of the householder characteristics for full sample in Table 5.9 (householder income and homeownership) are significant at the 1% level. In line with other happiness literature (Diaz-Serrano, 2009; Hu, 2013), householder income is one important determinant of one's housing satisfaction. To some extent, higher income means higher affordability for the better houses and also facilitates better furnishing and decoration, etc. of the house; also the deep-rooted notion of owning houses for Chinese people explains the significance of homeownership. Finally, as housing-related variables can represent the housing quality, these conditions can reflect the comfort experienced by people (Elsinga and Hoekstra, 2005); thus, it is consistent with previous findings (Hu, 2013). All the variables for housing conditions are positively significant for individual housing satisfaction, such as house size, number of bedrooms, having living rooms or bathrooms, and the type of houses. However, Hu suggests having bathrooms has no significant impact on housing satisfaction; our improved dataset amends Hu's results, since our sample excludes the missing and invalid answers of the questionnaire dataset (using 4442 valid answers from 6013 urban questionnaires).

Specifically, compared with people living in commercial houses and other houses, those living in economically affordable houses show a lower housing satisfaction. Wu *et al*. (2012) argued a possible explanation for this is the relative distance from city centres and the poor infrastructure regarding living facilities; since the affordable houses are usually provided for middle-low income families with much lower purchase prices than commercial buildings. In

[81] Suppose we have the equation $y = \alpha + \beta X + \delta X^2 + \varepsilon$, differentiate the equation with respect to *X*, then we can get $dy/dx = \beta + 2\delta X$; the extreme value exists when $dy/dx = \beta + 2\delta X = 0$, then $X = -\beta/2\delta$ at this point.

fact, the satisfaction with the area people live may affect the housing satisfaction as well. In the survey, there is a question of 'are you happy with the residential community you live in' indicating the quality of housing environment. Adding the satisfaction with housing environment as another explanatory variable, the regression results show that there is a significant positive effect of housing environment on individual's housing satisfaction. Thus, we can see that the housing type indicates the effects of the quality of houses on the housing satisfaction, while the housing environment indicates the effects of the quality of area people live on the housing satisfaction.

As explained in the methodology, the robustness checks are produced to detect the appropriateness of our results. Due to the high correlation coefficients between age and job status, house size and number of bedrooms, having living rooms and having bathrooms in Table 5.6, the explanatory variables of job status, number of bedrooms, and having bathrooms are excluded from the robust function. But the results are identical with the original estimations. Except for gender, marital status, and education level, the other independent variables still have significant impact on housing satisfaction. The alternative robustness check by making dependent variable as 0-1 binary variable has solely changed the effect of house type, where the house types have no significant effects any more.

Additionally, the coefficients of cut off points in the regressions also need to be interpreted. In our case, the ordered dependent variable of housing satisfaction has been divided into four categories (see Table 5.7): *(1) very unsatisfied, (2) unsatisfied, (3) satisfied, (4) very satisfied*. There are three cut off points ('*cut1, cut2, cut3*' in Table 5.9) for four sections. These correspond to the μ_i coefficients discussed earlier. We can explain that:

$$
\begin{aligned}
&\Pr(y=1)=\Pr(z<cut1)\\
&\Pr(y=2)=\Pr(cut1<z<cut2)\\
&\Pr(y=3)=\Pr(cut2<z<cut3)\\
&\Pr(y=4)=\Pr(cut3<z)
\end{aligned}
\tag{5.10}
$$

And for the predicted value of $\hat{y}$, the respondents will fall into category *(1)* if $\hat{y}<cut1$, into category *(2)* if $cut1<\hat{y}<cut2$, into category *(3)* if $cut2<\hat{y}<cut3$, into category *(4)* if $\hat{y}>cut3$. For example, from Table 5.9, we can tell that, the respondents feel '*very unsatisfied*' about housing satisfaction with $\hat{y}$ less than 1.899, '*unsatisfied*' with $\hat{y}$ between 1.899 and 3.207, '*satisfied*' with $\hat{y}$ between 3.207 and 4.929, '*very satisfied*' with $\hat{y}$ more than 4.929. More specifically, if the estimated value of y from Equation 5.5 is under 1.899, the people will feel '*very unsatisfied*' about their housing conditions. Of course, if we change the answers of housing satisfaction into binary options, either '*unsatisfied*' or '*satisfied*', the value of unique cut off point is 3.396 (in Table 5.9), which means householders feel '*unsatisfied*' under 3.396 and '*satisfied*' above 3.396.

In order to detect the different effects of housing characteristics between different groups, we will divide the full sample into two groups respectively, by age or income. Here, the age boundary is 42 and the income boundary is 10000 yuan/year. These boundaries roughly divide the sample into two equal halves, but also it is plausible, for example, to regard those aged 42 or less as 'young' and those over this age as 'old'. Prior to interpreting the coefficients of sub-sample regressions, an analogical method to the Chow test—running a regression and testing certain coefficients against zero—is used to test the significance of our divisions. Table 5.10 shows the results for testing the structural changes, and it suggests that our age and income divisions are both significant at the 10% level.

In addition, in order to estimate the separate and interactive effects of age groups and income groups in the overall regression, Table 5.11 demonstrates the results from Equation 5.9. Adding dummies generated from age and income groups do not change the effects of the determinants on housing satisfaction. The individual effects of two groups are only significant at the 10% level. And the interaction effect between the age dummy and the income is significant at the 10% level, but the interaction effect between the income dummy and the age is not significant. Overall, neither individual effects nor interactive effects have significant influence on housing satisfaction at the 5% level. But, of course this does not mean that the impact of other variables is the same in the two regressions.

By dividing respondents into two groups of youngsters and elders in Table 5.12, the effect of householder income is not significant for elder people; while the homeownership is still an influential factor for housing satisfaction for both groups. Interestingly, all the house-related characteristics are quite significant for old people; comparatively, only house size and number of bedrooms play a vital role in young people's housing satisfaction and it does not matter whether they have living rooms or bathrooms, or which type of houses they live in. That may be due to the elder people spending more time at home than young people, while younger people need to work or socialise more than older ones and spend less time at home (Chen and Short, 2008; Chyi and Mao, 2012).

In the groups of low-income and high-income householders in Table 5.12, homeownership and house size are quite significant for both groups at the 1% level. Apart from having living rooms, the other housing conditions have a significantly positive impact on low-income people's housing satisfaction. The number of bedrooms and having bathrooms has significant impacts on low-income populations rather than high-income populations. While the housing type and having living rooms has the opposite consequence, affecting rich people more significantly than poor people. Because affordable housing, as a kind of social welfare, is just for the middle-/low-income population, and richer people need to purchase commercial apartments from the housing market. This can explain why housing type does not have a prominent influence on rich people's housing satisfaction.

Table 5.9: The Effects on Housing Satisfaction with Total Sample

Variables		**Housing Satisfaction**					
		Total		**Robustness Checks**			
				Drop Indep. Var.		**Binary Dep. Var. (0-1)**	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.033(3.46)	0.001***	-0.034(3.61)	0.000***	-0.028(2.42)	0.016**
	Age square	0.0004(4.15)	0.000***	0.0005(4.47)	0.000***	0.0004(3.30)	0.001***
	Gender (default group: male)						
	Female	0.019(0.56)	0.574	0.029(0.84)	0.402	0.021(0.51)	0.609
	Marital Status (default group: unmarried)						
	Married	0.063(1.30)	0.194	0.065(1.34)	0.179	0.033(0.56)	0.573
	Education level (default group: low education)						
	Middle education	-0.050(-0.99)	0.320	-0.042(0.83)	0.408	-0.010(0.17)	0.867
	High education	0.066(1.00)	0.318	0.081(1.23)	0.218	0.131(1.65)	0.099*
	Self-rated health	0.448(17.29)	0.000***	0.445(17.20)	0.000***	0.382(12.21)	0.000***
	Job status (default group: unemployed)						
	Employed	0.019(0.42)	0.674	-	-	0.004(0.08)	0.938
Householder characteristics	**Log of householder income (yuan)**	0.058(2.63)	0.009***	0.065(3.09)	0.002***	0.078(2.93)	0.003***
	Homeownership (default group: no homeownership)						
	Homeownership	0.569(13.74)	0.000***	0.603(14.75)	0.000***	0.516(10.46)	0.000***
House-related characteristics	**House size (m^2)**	0.004(7.31)	0.000***	0.005(12.48)	0.000***	0.006(7.93)	0.000***
	Number of bedrooms	0.080(4.00)	0.000***	-	-	0.111(4.13)	0.000***
	Having living rooms	0.172(3.33)	0.001***	0.239(5.32)	0.000***	0.149(2.36)	0.018**
	Having bathrooms	0.174(3.17)	0.002***	-	-	0.232(3.48)	0.001***
	House type (default group: economical affordable housing)						
	Commercial housing	0.138(2.44)	0.015**	0.138(2.44)	0.015**	0.025(0.38)	0.707
	Others	0.124(2.47)	0.013**	0.106(2.13)	0.033**	0.007(0.11)	0.911
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		1.899(0.315)	6.04***	1.821(0.288)	6.31***	3.396(0.384)	8.85***
cut2		3.207(0.316)	10.14***	3.121(0.290)	10.76***	-	-
cut3		4.929(0.320)	15.41***	4.841(0.294)	16.47***	-	-
Number of Observations		4442		4442		4442	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.10: Group Division Tests for Housing Satisfaction

Group Division Tests for Housing Satisfaction		
Groups	**Chi-square**	**Prob>Chi-square**
By Age	27.18	0.0555*
By Income	26.76	0.0618*
Note: *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.		

Table 5.11: The Separate and Interactive Effects of Age and Income on Housing Satisfaction

Variables		**Without Dummies**		**With Dummies**	
		Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.033(3.46)	0.001***	-0.043(-4.11)	0.000***
	Age square	0.0004(4.15)	0.000***	0.0005(4.50)	0.000***
	Gender (default group: male)				
	Female	0.019(0.56)	0.574	0.015(0.44)	0.659
	Marital Status (default group: unmarried)				
	Married	0.063(1.30)	0.194	0.081(1.65)	0.100
	Education level (default group: low education)				
	Middle education	-0.050(-0.99)	0.320	-0.057(-1.10)	0.273
	High education	0.066(1.00)	0.318	0.067(1.01)	0.314
	Self-rated health	0.448(17.29)	0.000***	0.452(17.39)	0.000***
	Job status (default group: unemployed)				
	Employed	0.019(0.42)	0.674	0.011(0.25)	0.803
Householder characteristics	**Log of householder income (yuan)**	0.058(2.63)	0.009***	0.125(3.29)	0.001***
	Homeownership (default group: no homeownership)				
	Homeownership	0.569(13.74)	0.000***	0.571(13.77)	0.000***
House-related characteristics	**House size (m^2)**	0.004(7.31)	0.000***	0.004(7.28)	0.000***
	Number of bedrooms	0.080(4.00)	0.000***	0.080(4.00)	0.000***
	Having living rooms	0.172(3.33)	0.001***	0.712(3.32)	0.001***
	Having bathrooms	0.174(3.17)	0.002***	0.177(3.23)	0.001***
	House type (default group: economical affordable housing)				
	Commercial housing	0.138(2.44)	0.015**	0.143(2.52)	0.012**
	Others	0.124(2.47)	0.013**	0.129(2.55)	0.011**
Dummy Variables	**D(age)**	-	-	0.840(0.444)	0.059*
	D(income)	-	-	-0.277(-1.82)	0.069*
	D(age)*income	-	-	-0.079(-1.65)	0.098*
	D(income)*age	-	-	0.005(1.48)	0.140
Number of Observations		4442		4442	
Note: ( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.					

Table 5.12: The Effects on Housing Satisfaction by Groups

Variables		Housing Satisfaction							
		By age				By income (yuan)			
		Young (<=42)		Old (>42)		Low (<=10000)		High (>10000)	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.56(1.37)	0.171	0.033(0.72)	0.474	-0.34(2.73)	0.006***	-0.033(2.20)	0.028**
	Age square	0.001(1.13)	0.260	-0.0002(0.41)	0.685	0.0005(3.31)	0.001***	0.0005(2.63)	0.008***
	Gender (default group: male)								
	Female	0.054(1.12)	0.263	-0.014(0.27)	0.788	-0.009(0.20)	0.844	0.058(1.13)	0.260
	Marital Status (default group: unmarried)								
	Married	0.079(1.13)	0.257	0.095(1.29)	0.197	0.016(0.25)	0.801	0.122(1.69)	0.091*
	Education level (default group: low education)								
	Middle education	-0.048(0.48)	0.633	-0.056(0.92)	0.359	-0.029(0.48)	0.629	-0.119(1.10)	0.270
	High education	0.101(0.91)	0.364	0.080(0.08)	0.935	0.059(0.57)	0.568	0.011(0.10)	0.921
	Self-rated health	0.387(10.10)	0.000***	0.504(14.21)	0.000***	0.510(14.77)	0.000***	0.371(9.37)	0.000***
	Job status (default group: unemployed)								
	Employed	0.007(0.10)	0.924	0.016(0.26)	0.793	0.039(0.71)	0.476	-0.040(0.49)	0.621
Householder characteristics	**Log of householder income (yuan)**	0.088(2.86)	0.004***	0.025(0.77)	0.439	0.072(1.98)	0.048**	0.095(1.82)	0.068*
	Homeownership (default group: no homeownership)								
	Homeownership	0.625(11.26)	0.000***	0.487(7.65)	0.000***	0.561(9.61)	0.000***	0.568(9.47)	0.000***
House-related characteristics	**House size (m^2)**	0.004(5.64)	0.000***	0.003(4.58)	0.000***	0.004(5.71)	0.000***	0.004(4.78)	0.000***
	Number of bedrooms	0.071(2.39)	0.017**	0.090(3.27)	0.001***	0.095(3.60)	0.000***	0.050(1.62)	0.106
	Having living rooms	0.116(1.52)	0.128	0.220(3.09)	0.002***	0.059(0.85)	0.393	0.317(4.04)	0.000***
	Having bathrooms	0.027(0.34)	0.736	0.306(4.06)	0.000***	0.197(2.87)	0.004***	0.179(1.91)	0.056*
	House type (default group: economical affordable housing)								
	Commercial housing	0.109(1.42)	0.157	0.177(2.11)	0.034**	0.212(2.56)	0.011**	0.072(0.92)	0.357
	Others	0.085(1.22)	0.223	0.167(2.29)	0.022**	0.198(2.81)	0.005***	0.054(0.75)	0.456
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		1.512(0.689)	2.20**	3.535(1.308)	2.70***	2.075(0.443)	4.68***	2.107(0.641)	3.29***
cut2		2.857(0.690)	4.14***	4.815(1.309)	3.68***	3.430(0.445)	7.71***	3.368(0.642)	5.24***
cut3		4.494(0.693)	6.49***	6.632(1.311)	5.06***	5.120(0.450)	11.37***	5.138(0.647)	7.95***
Number of Observations		2202		2240		2386		2056	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

5.5.2 The Effects on Overall Happiness

Table 5.13 illustrates the effects of the various determinants on individual overall happiness. Broadly speaking, in line with the existing happiness literature in China (Appleton and Song, 2008; Knight *et al.*, 2009; Knight and Gunatilaka, 2011; Chyi and Mao, 2012; Wang and VanderWeele, 2011; Hu 2013), most of the individual characteristics, except for job status, significantly affect people's overall happiness, such as age, gender, marital status, education level and self-rated health. Similarly, the householder features of both annual income and homeownership exhibit a great degree of significance on overall happiness. Nevertheless, the housing-related characteristics have less impact on people's overall happiness than on housing satisfaction. For example, only house size has any effects in the full sample at the 5% significance level.

Again, the results of the robustness check by dropping highly correlated variables coincide with the original function. Most individual features are significant, and most housing-related factors are not. However, making the dependent variable as 0-1 binary variable has changed the effects of several housing-related determinants, where having bathrooms and other house types are significant at the 5% level. The coefficients of cut off points in Table 5.13 can be interpreted as that, people felt '*very unhappy*' about overall life satisfaction with $\hat{y}$ less than 0.520, '*unhappy*' with $\hat{y}$ between 0.520 and 1.463, '*neutral*' with $\hat{y}$ between 1.463 and 3.232, '*happy*' with $\hat{y}$ between 3.232 and 4.913, '*very happy*' with $\hat{y}$ more than 4.913. And if change the answers of housing satisfaction into binary options, either '*unhappy*' or '*happy*', the value of unique cut off point is 3.387 (in Table 5.13), which means householders feel '*unhappy*' under 3.387 and '*happy*' above 3.387.

Furthermore, the division tests for overall subjective wellbeing in Table 5.14 imply that, the age and income divisions are significant at the 1% and 5% level respectively. That indicates our divisions are more important for overall happiness estimations than housing satisfaction estimations. Again, from Table 5.15, both separate and interactive dummies make no change on the significance of factors. However, the dummies of individual income division and interactive relationship between income dummy and age have the significant impact on overall happiness at the 5% level, while the dummies of separate age division and interactive linkage between age dummy and income do not have.

For the groups of householders distinguished by age in Table 5.16, regardless of old or young people, the individual characteristics—gender, marital status, education level and self-rated health—have significant impacts on overall happiness; however, the age only affects the young populations under 42. Again, there is no evidence of the job status affecting individual's subjective well-being. The factors of income and homeownership have a strong influence on both age groups of interviewees at the 1% level. However, the only powerful determinants of housing-related features are house size and having bathrooms, where the former affects the old and the latter affects the young respectively.

For the categories of householders classified by income in Table 5.16, other than the job status, the other individual features have strong impacts on both rich and poor people's overall happiness. Meanwhile, the job status is more important to individual's overall happiness for high-income populations. Once again, similar to the full sample and people with different age groups, the householder characteristics of income and homeownership have a remarkable consistent influence on both rich and poor individuals. As mentioned above, the housing-related factors exhibit less impacts, only house size affects low-income householders at the 1% level and having living rooms affects high-income householders at the 5% level. Furthermore, having bathrooms marginally influences the rich people at the 10% level.

The stronger effects of individual features and the weaker impact of housing conditions on overall happiness indicate that people's overall life is more related to individual situations, and the housing conditions affect housing satisfaction more straightforwardly than overall life. This is not to say they might not be significant given a larger sample size. Even so, the homeownership is always powerful in explaining both subjective well-being indicators for all the groups of people. In addition, we can see that housing characteristics do impact on different groups of people, for instance, having a bathroom on the young and having living room on the rich, which may be reflective of life styles.

Table 5.13: The Effects on Overall Happiness with Total Sample

Variables		**Overall Happiness**					
		Total		**Robustness Checks**			
				Drop Indep. Var.		**Binary Dep. Var. (0-1)**	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.096(9.94)	0.000***	-0.096(10.04)	0.000***	-0.103(8.94)	0.000***
	Age square	0.001(9.56)	0.000***	0.001(9.82)	0.000***	0.001(8.68)	0.000***
	Gender (default group: male)						

	Female	0.174(4.97)	0.000***	0.171(4.94)	0.000***	0.160(3.85)	0.000***
	Marital Status (default group: unmarried)						
	Married	0.543(11.03)	0.000***	0.547(11.12)	0.000***	0.569(9.44)	0.000***
	Education level (default group: low education)						
	Middle education	0.195(3.82)	0.000***	0.191(3.75)	0.000***	0.202(3.30)	0.001***
	High education	0.356(5.36)	0.000***	0.350(5.29)	0.000***	0.431(5.47)	0.000***
	Self-rated health	0.432(16.56)	0.000***	0.433(16.62)	0.000***	0.423(13.46)	0.000***
	Job status (default group: unemployed)						
	Employed	-0.010(0.22)	0.822	-	-	-0.014(0.25)	0.799
Householder characteristics	**Log of householder income (yuan)**	0.199(8.91)	0.000***	0.198(9.26)	0.000***	0.223(8.35)	0.000***
	Homeownership (default group: no homeownership)						
	Homeownership	0.340(8.16)	0.000***	0.343(8.35)	0.000***	0.344(6.97)	0.000***
House-related characteristics	**House size (m^2)**	0.001(2.53)	0.011**	0.002(4.26)	0.000***	0.002(3.63)	0.000***
	Number of bedrooms	0.028(1.42)	0.157	-	-	0.043(1.82)	0.068*
	Having living rooms	0.067(1.29)	0.199	0.033(0.72)	0.472	0.112(1.80)	0.072*
	Having bathrooms	-0.064(1.17)	0.244	-	-	-0.134(2.04)	0.042**
	House type (default group: economical affordable housing)						
	Commercial housing	-0.013(0.23)	0.815	-0.009(0.16)	0.874	-0.013(0.19)	0.846
	Others	-0.098(1.92)	0.055*	-0.087(1.72)	0.085*	-0.135(2.26)	0.024**
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		0.520(0.320)	1.62	0.524(0.294)	1.78*	3.387(0.378)	8.96***
cut2		1.463(0.317)	4.62***	1.468(0.291)	5.05***	-	-
cut3		3.232(0.319)	10.13***	3.236(0.294)	11.02***	-	-
cut4		4.913(0.323)	15.23***	4.916(0.297)	16.54***	-	-
Number of Observations		4442		4442		4442	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.14: Group Division Tests for Overall Happiness

Group Division Tests for Overall Happiness		
Groups	**Chi-square**	**Prob>Chi-square**
By Age	34.96	0.0063***
By Income	28.77	0.0367**

Note:
*** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.15: The Separate and Interactive Effects of Age and Income on Overall Happiness

Variables		**Without Dummies**		**With Dummies**	
		Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.096(9.94)	0.000***	-0.106(-10.01)	0.000***
	Age square	0.001(9.56)	0.000***	0.001(9.75)	0.000***
	Gender (default group: male)				
	Female	0.174(4.97)	0.000***	0.177(5.03)	0.000***
	Marital Status (default group: unmarried)				
	Married	0.543(11.03)	0.000***	0.547(10.93)	0.000***
	Education level (default group: low education)				
	Middle education	0.195(3.82)	0.000***	0.169(3.25)	0.001***
	High education	0.356(5.36)	0.000***	0.331(4.94)	0.000***
	Self-rated health	0.432(16.56)	0.000***	0.432(16.51)	0.000***
	Job status (default group: unemployed)				
	Employed	-0.010(0.22)	0.822	-0.019(-0.42)	0.676
Householder characteristics	**Log of householder income**	0.199(8.91)	0.000***	0.213(5.52)	0.000***

	(yuan)				
	Homeownership (default group: no homeownership)				
	Homeownership	0.340(8.16)	0.000***	0.344(8.25)	0.000***
House-related characteristics	**House size (m^2)**	0.001(2.53)	0.011**	0.001(2.51)	0.012**
	Number of bedrooms	0.028(1.42)	0.157	0.027(1.36)	0.174
	Having living rooms	0.067(1.29)	0.199	0.072(1.37)	0.171
	Having bathrooms	-0.064(1.17)	0.244	-0.067(-1.21)	0.228
	House type (default group: economical affordable housing)				
	Commercial housing	-0.013(0.23)	0.815	-0.004(-0.08)	0.938
	Others	-0.098(1.92)	0.055*	-0.093(-1.84)	0.066*
Dummy Variables	**D(age)**	-	-	0.409(0.91)	0.362
	D(income)	-	-	-0.335(-2.17)	0.030**
	D(age)*income	-	-	-0.036(-0.74)	0.458
	D(income)*age	-	-	0.008(2.53)	0.011**
Number of Observations		4442		4442	

Note:
( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.16: The Effects on Overall Happiness by Groups

Variables		Overall Happiness							
		By age				By income (yuan)			
		Young (<=42)		Old (>42)		Low (<=10000)		High (>10000)	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Individual characteristics	**Age**	-0.138(3.31)	0.001***	0.053(1.14)	0.254	-0.098(7.80)	0.000***	-0.098(6.38)	0.000***
	Age square	0.002(2.45)	0.014**	-0.0003(0.75)	0.453	0.001(7.32)	0.000***	0.001(6.42)	0.000***
	Gender (default group: male)								
	Female	0.104(2.11)	0.035**	0.249(4.90)	0.000***	0.163(3.42)	0.001***	0.216(4.09)	0.000***
	Marital Status (default group: unmarried)								
	Married	0.594(8.28)	0.000***	0.569(7.63)	0.000***	0.527(7.95)	0.000***	0.568(7.58)	0.000***
	Education level (default group: low education)								
	Middle education	0.269(2.65)	0.008***	0.167(2.74)	0.006***	0.169(2.85)	0.004***	0.140(1.29)	0.198
	High education	0.506(4.47)	0.000***	0.212(2.19)	0.028**	0.390(3.75)	0.000***	0.283(2.44)	0.015**
	Self-rated health	0.382(9.81)	0.000***	0.475(13.39)	0.000***	0.434(12.71)	0.000***	0.419(10.28)	0.000***
	Job status (default group: unemployed)								
	Employed	-0.101(1.43)	0.152	-0.008(0.13)	0.898	0.074(1.36)	0.173	-0.227(2.74)	0.006***
Householder characteristics	**Log of householder income (yuan)**	0.165(5.21)	0.000***	0.235(7.16)	0.000***	0.210(5.73)	0.000***	0.154(2.88)	0.004***
	Homeownership (default group: no homeownership)								
	Homeownership	0.352(6.27)	0.000***	0.314(4.93)	0.000***	0.326(5.61)	0.000***	0.364(5.94)	0.000***
House-related characteristics	**House size (m^2)**	0.001(1.29)	0.195	0.002(2.43)	0.015**	0.002(2.89)	0.004***	0.001(0.79)	0.432
	Number of bedrooms	0.044(1.48)	0.140	0.013(0.49)	0.623	0.019(0.71)	0.476	0.029(0.92)	0.356
	Having living rooms	0.079(1.01)	0.312	0.058(0.81)	0.420	-0.015(0.21)	0.831	0.203(2.52)	0.012**
	Having bathrooms	-0.165(2.01)	0.044**	0.014(0.19)	0.850	-0.019(0.28)	0.783	-0.172(1.80)	0.073*
	House type (default group: economical affordable housing)								
	Commercial housing	-0.043(0.54)	0.588	0.018(0.22)	0.826	0.044(0.53)	0.596	-0.048(0.60)	0.547
	Others	-0.107(1.51)	0.132	-0.091(1.24)	0.214	-0.084(1.19)	0.234	-0.105(1.42)	0.154
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		-0.738(0.705)	-1.05	5.079(1.312)	3.87***	0.506(0.444)	1.14	-0.035(0.664)	-0.05
cut2		0.085(0.700)	0.12	6.119(1.312)	4.66***	1.534(0.442)	3.47***	0.717(0.655)	1.10
cut3		1.907(0.701)	2.72***	7.871(1.316)	5.98***	3.272(0.445)	7.35***	2.581(0.656)	3.94***
cut4		3.617(0.703)	5.14***	9.525(1.319)	7.22***	4.801(0.449)	10.69***	4.414(0.660)	6.69***
Number of Observations		2202		2240		2386		2056	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

5.5.3 The Effects on Overall Happiness of Including Housing Satisfaction as an Explanatory Variable

Adding housing satisfaction as one of the explanatory variables, as in Table 5.17 demonstrates that housing satisfaction is a major determinant of one's overall happiness for all groups of the population regardless of their age or income level; because the coefficients of housing satisfaction are all significant at the 1% level. This finding reconfirms Hu (2013)'s conclusion that housing satisfaction is quite important for an individual's overall subjective wellbeing. From the perspective of all respondents, Table 5.17 shows some similar findings with Table 5.13—apart from the job status, the other individual characteristics (age, gender, marital status, education level, health status) significantly affect the overall happiness of householders. Furthermore, the householder income and homeownership, as always, have significantly positive effects.

Additionally, in Table 5.17, the results of both robustness checks are quite in accordance with the original function. Besides in the regression with the 0-1 binary dependent variable, the housing size and having bathrooms exhibit more significant effects on overall happiness at the 5% level. The interpretation for the coefficients of cut off points is that, individuals fell '*very unhappy*' about overall life satisfaction with $\hat{y}$ less than 0.680, '*unhappy*' with $\hat{y}$ between 0.680 and 1.630, '*neutral*' with $\hat{y}$ between 1.630 and 3.441, '*happy*' with $\hat{y}$ between 3.441 and 5.172, '*very happy*' with $\hat{y}$ more than 5.172. And the binary regression illustrates that people feel '*unhappy*' under 3.080 and '*happy*' above 3.080.

Moreover, the results of the division tests in Table 5.18 demonstrate that, both age and income divisions are significant at the 5% level, which is also significant for overall happiness estimations including housing satisfaction as one of independent variables. Additionally, the separate and interactive effects from Table 5.19 indicate that, only the multiplication of income dummy and age has played a significant role in overall subjective wellbeing at the 5% level, by adding hosuing satisfaction as one of explanatory variables.

Regarding of Table 5.20, from the point of view of different age groups, most of the individual characteristics and householder features have significant positive effects on overall happiness; although the age factor just impacts on the young respondents and the job status has no explanatory power for both groups. Moreover, most of the housing-related features have no significant impact, except having bathrooms affects the younger people significantly at the 5% level. Similar results are obtained for alternative groups of individuals identified by the annual income, most of the individual features significantly affect the overall life satisfaction of both groups of people; one of the exceptions is the middle level of education only affects the low-income population, and the other exception is the job status strongly impacts the high-income group at the 1% level. Again, both the income and homeownership play an important role in people's overall life satisfaction with different income levels. By contrast, the housing-related characteristics are much less important for people's overall life satisfaction. Only having living rooms and having bathrooms have an influence on rich people at the 1% and 5% significance level respectively. Of course these variables are in addition to housing satisfaction itself. Hence we would not expect them to be significant if their only impact upon overall wellbeing was through the quality of the house and satisfaction. Hence the significance of homeownership indicates it adds to wellbeing independently of its impact on housing satisfaction.

As a general view, the major conclusion is that housing characteristics impact on different types of people differently. The findings of these three models show the variables of housing-related conditions affect individual's housing satisfaction directly and significantly; however, the overall happiness seems to be affected by individual characteristics' variables rather than housing conditions. Even so, housing satisfaction has a significant impact on overall happiness by adding it as one of the explanatory variables. While householder features—annual income and homeownership—persistently affect both subjective wellbeing indicators, which emphasizes the importance of income and homeownership for people's life in urban China.

Table 5.17: The Effects on Overall Happiness including Housing Satisfaction as an Explanatory Variable with Total Sample

Variables		**Overall Happiness with Housing Satisfaction**					
		Total		**Robustness Checks**			
				Drop Indep. Var.		**Binary Dep. Var. (0-1)**	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Housing satisfaction		0.331(13.67)	0.000***	0.329(13.65)	0.000***	0.561(12.96)	0.000***
Individual characteristics	**Age**	-0.091(9.40)	0.000***	-0.091(9.47)	0.000***	-0.100(8.61)	0.000***
	Age square	0.001(8.86)	0.000***	0.001(9.07)	0.000***	0.001(8.16)	0.000***
	Gender (default group: male)						
	Female	0.174(4.95)	0.000***	0.169(4.86)	0.000***	0.157(3.75)	0.000***
	Marital Status (default group: unmarried)						
	Married	0.545(11.01)	0.000***	0.548(11.09)	0.000***	0.579(9.49)	0.000***
	Education level (default group: low education)						
	Middle education	0.210(4.09)	0.000***	0.204(3.98)	0.000***	0.217(3.49)	0.000***
	High education	0.350(5.24)	0.000***	0.341(5.12)	0.000***	0.419(5.25)	0.000***

	Self-rated health	0.350(13.01)	0.000***	0.352(13.10)	0.000***	0.357(11.13)	0.000***
	Job status (default group: unemployed)						
	Employed	-0.014(0.31)	0.756	-	-	-0.014(0.25)	0.801
Householder characteristics	**Log of householder income (yuan)**	0.192(8.54)	0.000***	0.189(8.79)	0.000***	0.214(7.90)	0.000***
	Homeownership (default group: no homeownership)						
	Homeownership	0.225(5.27)	0.000***	0.221(5.23)	0.000***	0.240(4.75)	0.000***
House-related characteristics	**House size (m^2)**	0.001(1.09)	0.277	0.001(1.70)	0.090*	0.001(2.18)	0.029**
	Number of bedrooms	0.012(0.58)	0.565	-	-	0.022(0.92)	0.356
	Having living rooms	0.031(0.59)	0.557	-0.020(0.44)	0.657	0.076(1.21)	0.226
	Having bathrooms	-0.107(1.92)	0.055*	-	-	-0.182(2.72)	0.006***
	House type (default group: economical affordable housing)						
	Commercial housing	-0.041(0.71)	0.478	-0.036(0.63)	0.528	-0.014(0.20)	0.842
	Others	-0.124(2.43)	0.015**	-0.108(2.14)	0.032**	-0.136(2.25)	0.024**
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		0.680(0.322)	2.11**	0.697(0.296)	2.35**	3.080(0.384)	8.03***
cut2		1.630(0.319)	5.11***	1.648(0.293)	5.63***	-	-
cut3		3.441(0.321)	10.71***	3.459(0.296)	11.69***	-	-
cut4		5.172(0.325)	15.91***	5.188(0.300)	17.30***	-	-
Number of Observations		4442		4442		4442	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.18: Group Division Tests for Overall Happiness with Housing Satisfaction

Group Division Tests for Overall Happiness with Housing Satisfaction		
Groups	**Chi-square**	**Prob>Chi-square**
By Age	30.15	0.0360**
By Income	29.07	0.0475**

Note:
*** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.19: The Separate and Interactive Effects of Age and Income on Overall Happiness with Housing Satisfaction

Variables		**Without Dummies**		**With Dummies**	
		Coef.	Pro.	Coef.	Pro.
Housing Satisfaction		0.331(13.67)	0.000***	0.330(13.63)	0.000***
Individual characteristics	**Age**	-0.091(9.40)	0.000***	-0.099(-9.34)	0.000***
	Age square	0.001(8.86)	0.000***	0.001(8.98)	0.000***
	Gender (default group: male)				
	Female	0.174(4.95)	0.000***	0.178(5.03)	0.000***
	Marital Status (default group: unmarried)				
	Married	0.545(11.01)	0.000***	0.545(10.83)	0.000***
	Education level (default group: low education)				
	Middle education	0.210(4.09)	0.000***	0.184(3.53)	0.000***
	High education	0.350(5.24)	0.000***	0.325(4.81)	0.000***
	Self-rated health	0.350(13.01)	0.000***	0.349(12.94)	0.000***
	Job status (default group: unemployed)				
	Employed	-0.014(0.31)	0.756	-0.022(-0.47)	0.636
Householder characteristics	**Log of householder income (yuan)**	0.192(8.54)	0.000***	0.192(4.95)	0.000***
	Homeownership (default group: no homeownership)				
	Homeownership	0.225(5.27)	0.000***	0.229(5.37)	0.000***
House-related	**House size (m^2)**	0.001(1.09)	0.277	0.001(1.07)	0.283

characteristics	**Number of bedrooms**	0.012(0.58)	0.565	0.011(0.52)	0.603
	Having living rooms	0.031(0.59)	0.557	0.036(0.68)	0.499
	Having bathrooms	-0.107(1.92)	0.055*	-0.110(-1.97)	0.049**
	House type (default group: economical affordable housing)				
	Commercial housing	-0.041(0.71)	0.478	-0.033(-0.57)	0.571
	Others	-0.124(2.43)	0.015**	-0.121(-2.36)	0.018**
Dummy Variables	**D(age)**	-	-	0.244(0.54)	0.587
	D(income)	-	-	-0.285(-1.84)	0.066*
	D(age)*income	-	-	-0.020(-0.42)	0.677
	D(income)*age	-	-	0.007(2.27)	0.023**
Number of Observations		4442		4442	

Note:
( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

Table 5.20: The Effects on Overall Happiness including Housing Satisfaction as an Explanatory Variable by Groups

Variables		Overall Happiness							
		By age				By income (yuan)			
		Young (<=42)		Old (>42)		Low (<=10000)		High (>10000)	
		Coef.	Pro.	Coef.	Pro.	Coef.	Pro.	Coef.	Pro.
Housing Satisfaction		0.319(9.36)	0.000***	0.337(9.73)	0.000***	0.356(10.80)	0.000***	0.295(8.19)	0.000***
Individual characteristics	**Age**	-0.129(3.07)	0.002***	0.046(0.99)	0.324	-0.093(7.35)	0.000***	-0.094(6.08)	0.000***
	Age square	0.001(2.24)	0.025**	-0.0002(0.65)	0.513	0.001(6.72)	0.000***	0.001(6.04)	0.000***
	Gender (default group: male)								
	Female	0.096(1.94)	0.052*	0.256(5.02)	0.000***	0.169(3.54)	0.000***	0.210(3.95)	0.000***
	Marital Status (default group: unmarried)								
	Married	0.591(8.20)	0.000***	0.564(7.53)	0.000***	0.537(8.07)	0.000***	0.559(7.42)	0.000***
	Education level (default group: low education)								
	Middle education	0.282(2.76)	0.006***	0.183(2.99)	0.003***	0.181(3.02)	0.003***	0.162(1.48)	0.140
	High education	0.493(4.34)	0.000***	0.214(2.21)	0.027**	0.386(3.69)	0.000***	0.284(2.44)	0.015**
	Self-rated health	0.313(7.87)	0.000***	0.382(10.36)	0.000***	0.332(9.33)	0.000***	0.360(8.66)	0.000***
	Job status (default group: unemployed)								
	Employed	-0.104(1.47)	0.143	-0.011(0.17)	0.863	0.068(1.24)	0.215	-0.224(2.69)	0.007***
Householder characteristics	**Log of householder income (yuan)**	0.150(4.73)	0.000***	0.235(7.13)	0.000***	0.200(5.43)	0.000***	0.139(2.60)	0.009***
	Homeownership (default group: no homeownership)								
	Homeownership	0.227(3.93)	0.000***	0.216(3.34)	0.001***	0.205(3.45)	0.001***	0.262(4.18)	0.000***
House-related characteristics	**House size (m^2)**	0.0001(0.20)	0.843	0.001(1.54)	0.125	0.001(1.68)	0.092	-0.00004(0.05)	0.958
	Number of bedrooms	0.030(1.00)	0.317	-0.006(0.20)	0.838	-0.002(0.08)	0.934	0.019(0.61)	0.542
	Having living rooms	0.055(0.70)	0.486	0.011(0.16)	0.874	-0.028(0.40)	0.691	0.141(1.74)	0.082*
	Having bathrooms	-0.176(2.14)	0.033**	-0.056(0.73)	0.466	-0.068(0.98)	0.328	-0.212(2.21)	0.027**
	House type (default group: economical affordable housing)								
	Commercial housing	-0.064(0.81)	0.419	-0.016(0.19)	0.848	-0.0004(0.01)	0.996	-0.061(0.76)	0.449
	Others	-0.125(1.74)	0.081*	-0.127(1.72)	0.086*	-0.129(1.81)	0.071	-0.116(1.56)	0.120
Cut Off Points		Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics	Coef. (S. E.)	z statistics
cut1		-0.519(0.709)	-0.73	4.979(1.318)	3.78***	0.641(0.447)	1.43	0.064(0.667)	0.10
cut2		0.303(0.705)	0.43	6.030(1.319)	4.57***	1.679(0.445)	3.77***	0.815(0.658)	1.24
cut3		2.162(0.705)	3.06***	7.827(1.323)	5.92***	3.464(0.449)	7.72***	2.715(0.659)	4.12***
cut4		3.922(0.708)	5.54***	9.529(1.326)	7.19***	5.049(0.453)	11.15***	4.588(0.663)	6.92***
Number of Observations		2202		2240		2386		2056	

Note:
(1) For explanatory variables, ( ) denotes the t statistics of the respective coefficients; for cut off points, ( ) denotes the standard errors.
(2) *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

5.5.4 The Effects on Overall Happiness Using the Predicted Value of Housing Satisfaction

As mentioned before, people satisfied with their overall life may more easily feel happy about their houses, thus housing satisfaction may be correlated with the error term in the life satisfaction regression. In order to resolve the potential endogeneity problem, we generated the predicted value $\hat{y}_i$ from the housing satisfaction equation by using the Ramsey RESET procedure. Firstly, we have already obtained the estimated value of housing satisfaction from Equation 5.5 in Table 5.9. Then, as Ramsey RESET procedure suggest, the squared and cubed terms of housing satisfaction has been generated as Equation 5.9, to get the predicted value of $\hat{y}_i$. However, the test for the joint significance of $\hat{y}_i^2$ and $\hat{y}_i^3$ will indicate whether Equation 5.5 is misspecified or not.

The main purpose of this regression is to generate predicted values for inclusion in a regression with life satisfaction as the dependent variable. Rejecting the null implies that $\hat{y}_i^2$ and $\hat{y}_i^3$ are jointly significant and the original function is misspecified; hence the predicted value of $\hat{y}_i$ from the artificial model of Equation 5.9 should be adopted to estimate the regression for overall happiness, and the new regression rescues the misspecification problem to some extent. The results from whether the individual tests for $\hat{y}_i^2$ and $\hat{y}_i^3$, or the joint test for $\hat{y}_i^2$ and $\hat{y}_i^3$, all show that they are significant at the 1% level. That suggests us to use the predicted value of $\hat{y}_i$ from Ramsey RESET test in Equation 5.9.

Table 5.21: Ramsey RESET Test for Misspecification

Individual Test	**z statistic**	**Prob>|z|**
y^2	30.15	0.000***
y^3	29.07	0.000***
Joint Test	**Chi-square**[82]	**Prob>Chi-square**
y^2 and y^3	36.64	0.000***

Note:
*** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

[82] Tests for weak instruments: Stock *et al.* (2002) suggested that with two degrees of freedom on F statistics greater than 11.59 indicates instruments are not 'weak'. Testing for weak instruments with limited dependent variables is still a developing area of research. However, the Chi-sqaure test statistics can be linked to the F test in the limt as equal to 'degrees of freedom×F statistics' (Gould, 2013b). This suggests that Chi-square test statistics of 36.64 translates into an F statistic of 18.32, well above Stock *et al.*'s critical value suggesting the instruments are not weak, as was also suggested by their t statistics.

Table 5.22 compares the regression using the predicted value of housing satisfaction with the original one, and two regressions show the quite similar results: the housing satisfaction plays an important role in people's overall happiness; except for the employment, the other individual characteristics and the income have a significant impact on people's overall life satisfaction; for housing-related features, only having bathroom and other housing type have significant effects on overall happiness. The only difference is the impact of homeownership; the modified equation suggests homeownership cannot significantly influence overall happiness any more. That is probably because the impacts of homeownership and housing conditions have already been captured by another predicted explanatory variable of housing satisfaction.

Table 5.22: Comparisons of the Overall Happiness Regressions between the Regression using the Predicted Value of Housing Satisfaction and the Original Regression

Explanatory Variables		**Regression using the predicted value of housing satisfaction**		**The original regression with housing satisfaction**	
		Coef.	**Pro.**	**Coef.**	**Pro.**
Housing satisfaction		0.479(2.94)	0.003***	0.331(13.67)	0.000***
Individual characteristics	Age	-0.080(-7.28)	0.000***	-0.091(-9.40)	0.000***
	Age square	0.001(6.33)	0.000***	0.001(8.86)	0.000***
	Female	0.165(4.68)	0.000***	0.174(4.95)	0.000***
	Married	0.514(10.23)	0.000***	0.545(11.01)	0.000***
	Middle education	0.220(4.24)	0.000***	0.210(4.09)	0.000***
	High education	0.325(4.83)	0.000***	0.350(5.24)	0.000***
	Self-rated health	0.218(2.82)	0.005***	0.350(13.01)	0.000***
	Employed	-0.019(-0.41)	0.680	-0.014(-0.31)	0.756
Householder characteristics	Log of householder income (yuan)	0.172(7.08)	0.000***	0.192(8.54)	0.000***
	Homeownership	0.067(0.65)	0.513	0.225(5.27)	0.000***
House-related characteristics	House size (m^2)	-0.0005(-0.61)	0.545	0.001(1.09)	0.277
	Number of bedrooms	-0.010(-0.42)	0.674	0.012(0.58)	0.565
	Having living rooms	-0.016(-0.27)	0.790	0.031(0.59)	0.557
	Having bathrooms	-0.148(-2.38)	0.017**	-0.107(-1.92)	0.055*
	Commercial housing	-0.080(-1.30)	0.195	-0.041(-0.71)	0.478
	Others	-0.157(-2.88)	0.004***	-0.124(-2.43)	0.015**
Number of observations		4442 (full sample)			

Note:
( ) denotes the t statistics of the respective coefficients. *** indicates significance at 1% level, ** indicates significance at 5% level. * indicates significance at 10% level.

To some extent, the use of the modified predicted value of housing satisfaction solves the endogeneity problem and improves our estimations. Additionally, the modified explanatory variable of housing satisfaction captures the effects of homeownership and housing-related characteristics. It is difficult to capture the impact of characteristics such as house size, having a bathroom, the number of rooms, as they will tend to be correlated. Nonetheless we have established that these impact on housing satisfaction and the latter impacts on overall life satisfaction. Hence, these housing characteristics also impact on people's overall wellbeing.

5.5.5 The Money Equivalent Effects of Housing Conditions on Overall Happiness

In order to investigate the interactive relationship between the income and housing conditions, this chapter employs the money equivalent analysis to estimate what kind of housing conditions can cause the same degree of individual overall happiness with a certain level of income. Table 5.13 and Table 5.16 illustrate the regression results of the impacts of different determinants on people's overall happiness. As we can see from the coefficients, only one of the housing conditions, namely house size, plays a significant role in the overall happiness of the full sample, old or low-income interviewees; therefore, the monetary equivalent analysis shows that one more m^2 of a house will increase the same level of life satisfaction with a certain level of annual income. Although with the homeownership, one of the householder features significantly affects the life satisfaction of all groups of the population, but due to the discreteness of this variable, it does not make sense to estimate the money equivalence of it.

Since the money equivalent estimation focuses on the linkage between the house size and the annual income of the full sample, old or low-income groups, the coefficients of these two variables from different groups can be obtained from the regressions in Table 5.17. Let the coefficient of house size is α and the coefficient of the log of annual income is β. One more m^2 of house size can increase the happiness by an α unit. However, an α unit increase of happiness can also be caused by an *α/β* unit increase of the log of income. That is a one m^2 increase in house size increases wellbeing by the same amount as an increase in the log of income of *α/β*. As indicated by the survey data, if the average annual income of the group is γ, then the natural log of average annual incomes is $\ln(\gamma)$. With an α/β unit increase, the log of income is $\ln(\gamma)+\alpha/\beta$, and the annual income after the increase is $e^{\ln(\gamma)+\alpha/\beta}$, which is equal to $\gamma\times e^{\alpha/\beta}$. Eventually, the income has been increased by $\gamma(e^{\alpha/\beta}-1)$ or ($\gamma\times e^{\alpha/\beta}-\gamma$). Specifically, one more m^2 of house size can make people as happy as the $\gamma(e^{\alpha/\beta}-1)$ increase of income. Table 5.23 displays the process of the money equivalent analysis with regard to house size affecting people's overall happiness.

Table 5.23: The Money Equivalent Effects of House Size on Overall Happiness

The process of money equivalent analysis	Total	Old population (>42)	Low-income population (<=10000)
the coefficient of house size (from Table 5.17)	0.0012190	0.0017462	0.0019014
the coefficient of the log of income (from Table 5.17)	0.1994581	0.2346353	0.2100606
one more m^2 increase the happiness by	0.0012190	0.0017462	0.0019014
the increased happiness can be caused by the increase of the log of income by	0.006111559 *(=0.0012190/0.1994581)*	0.007442188 *(=0.0017462/0.2346353)*	0.009051674 *(=0.0019014/0.2100606)*
the average annual income in the different groups (from Table 5.7)	14204	11706	6175
the log of average annual income	9.561278894 *(=ln(14204))*	9.36785681 *(=ln(11706))*	8.728264161 *(=ln(6175))*
the log of income after increase	9.567390453 *(=9.561278894 +0.006111559)*	9.375298998 *(=9.36785681+0.007442188)*	8.737315835 *(=8.728264161+0.009051674)*
the income after increase	14291.0744 $(=e^{9.567390453})$	11793.44323 $(=e^{9.375298998})$	6231.147817 $(=e^{8.737315835})$
the increase of income above the average value	87.0744 *(=14291.0744-14204)*	87.44323 *(=11793.44323-11706)*	56.147817 *(=6231.147817-6175)*
The money equivalent effects of one more m^2 in house size is equal to the increase of income by: (yuan)	**87.07**	**87.44**	**56.15**

As indicated by the survey data, the average annual incomes of the full sample, old and low-income groups are 14204, 11706 and 6175 yuan respectively; Table 5.23 deduces that the money equivalent effects of the house size with one more m^2 on individual's overall happiness are 87.07, 87.44 and 56.15 yuan income for the three groups respectively. The second number is more than the first, despite income being lower as they are based on different regressions. That implies that one more m^2 of house size can increase the same degree of life satisfaction as an 87 yuan increase of income for overall respondents and old people; however, it produces the smallest increase in income (56 yuan) for the low-income population to get the same level of happiness by one more m^2. We can see that the average income of poor people (6175 yuan) is much lower than the overall level (14204 yuan) and the old people group (11706 yuan); to this extent, in order to get the same level of happiness with one more m^2 of house size, it takes less of an increase of income (56 yuan) to satisfy the low-income people than the overall and older age groups (87 yuan). That indicates it might be easier for the low-income householders to be satisfied with their overall life with less of an income increase.

5.6 Conclusion

Since the housing reform of the late 1980s in urban China, the housing system has gradually transferred from the social welfare housing system to a market-oriented commercial housing system. With the development of the housing market, the housing standards of urban people have been greatly improved. Since then, the Chinese commodity house prices have experienced a rapid growth. To a great extent, the living conditions affect all aspects of people's life. This chapter is the first attempt to investigate how the residential environment impacts on individual subjective wellbeing in urban China, such as housing satisfaction and overall happiness.

This chapter adopts the ordered probit model to estimate the effects of various determinants on subjective wellbeing indicators, by using the questionnaire dataset of the 2006 CGSS for householders in urban China. The individual subjective indicators used in this chapter include housing satisfaction, denoting the specific demand for housing, and the overall happiness, denoting the satisfaction about the general life situation. The possible factors affecting housing satisfaction have been grouped into three categories: individual characteristics (age, gender, marital status, education level, self-rated health and job status), householder characteristics (householder annual income and homeownership) and house-related characteristics (house size, number of bedrooms, having living rooms, having bathrooms, house type). Three models have been regressed by using different indicators as the dependent variables: (i) using housing satisfaction, (ii) using overall happiness, and (iii) using overall happiness again but including housing satisfaction as one of the explanatory variables.

For the full sample, the empirical results suggest that both householder features and housing conditions have significant effects on someone's housing satisfaction, which indicate these factors are empirically closely related to people's housing satisfaction For example, according to the 'Report on the Status of the Cities in China 2010/2011', by the end of 2008, 4.5% and 83% of urban householders live in single buildings and apartment units respectively, which are much more than householders (12.5%) living in tube-shaped apartments or bungalows. The great improvement of housing type has significantly increased people's housing and life satisfaction. However, housing conditions have less impact on people's overall happiness and the individual characteristics become significant except for the job status. Householder income and homeownership still play an important role in both housing satisfaction and overall happiness. That indicates housing-related features just influence housing satisfaction in a straightforward way rather than general life, and these factors are good indicators to explain personal housing satisfaction. But, including housing satisfaction as independent variables, suggests it is also one of the major significant variables for explaining the overall life satisfaction, which is consistent with our assumption that housing satisfaction is closely related to people's overall life. Furthermore, both robustness checks, by dropping high correlated variables or transferring ordered dependent variable as 0-1 binary variable, have confirmed the above findings.[83]

It is not surprising that it is difficult to identify the individual significance of characteristics such as house size, number of rooms, whether a bathroom etc, as they are closely correlated. But in establishing their impact on housing satisfaction and of that on life satisfaction, we have made the case that housing characteristics do actually impact on peoples' wellbeing. Moreover we have shown that they impact on different groups of people in different ways. This is important, regression analysis often proceeds on the assumption that the same equation is equally applicable to all. Our analysis has shown that this is not always the case.

By dividing the full sample of interviewees into groups, the housing factors have distinct effects on different population's housing satisfaction. Prior to interpreting the regressions for different groups, the Chow tests justify that the divisions of the sample by age and income are significant for three models, especially for the estimations of the effects on overall happiness. However, the dummy variables for the individual and interactive effects of age groups and income groups indicate that, their effects are not always significant in the regressions.

More specifically, for young people, the housing conditions are less important than for the elders; since they seem to care less about the type of house and having living rooms/bathrooms or not. While, old people care about all aspects of housing conditions; and one possible reason is that elders spend more time at home than the youngsters. In terms of income groups, the general picture is that there are more significant housing variables for lower-income householders but not for higher-income householders. For example, apart from

[83] I have also estimated the regression by using robust errors, which corrects the standard errors and t statistics for certain problems. That still does not change the significance of other explanatory variables.

having living rooms, homeownership, house size, number of bedrooms, having bathrooms and housing type all have significant positive effects on poor people; by contrast, only homeownership, house size and having bathrooms significantly affect rich people's housing satisfaction. This again makes sense in that richer people have a greater ability to buy the houses they want. Hence, if they choose a small house, that is what they want, whereas for a poorer person that is what they may be constrained to have.

Another important step is to resolve the misspecification problem of housing satisfaction and overall happiness. As the Ramsey RESET test suggests, adding the squared and cubed dependent variable is used to improve the predicted values from the regression of housing satisfaction on exogenous variables. Thus, the actual value of housing satisfaction has been replaced by the modified fitted value in the new overall life satisfaction regression. And the new regression presents quite similar findings with the original one, and suggests the effects of homeownership and housing conditions may be captured by the predicted housing satisfaction.

Finally, the money equivalent analysis of house size indicates that one more m^2 of house size can cause the same increase of life satisfaction as an 87.07, 87.44 and 56.15 yuan increase of annual income for the full sample, older group and low-income group respectively. Meanwhile, the average annual income of the low-income householder (6175 yuan) is much less than the full sample group (14204 yuan) or old group (11706 yuan), which indicates that it is easier for poorer people to feel satisfaction with overall life, if they are given a little more money.

To sum up, the householder income and homeownership significantly affect both subjective wellbeing indicators—housing satisfaction and overall happiness, regardless of the groups of the population. As MOC (2006) points out, the ratio of homeowners in urban residents with '*Hukou*' is as high as 81.62% in 2005, and has reached to 87.8% by the 'Report on the Status of the Cities in China 2010/2011'. The importance of homeownership corroborates the traditional idea of Chinese people preferring to purchasing houses rather than renting. Overall, the housing conditions used in our model significantly impact on householders' housing satisfaction, which indicates the close relationship between housing qualities and subjective wellbeing. In addition if you own your own house, you can make changes as you wish to the house, which you cannot do if it is not yours. Nevertheless, the specific housing conditions heterogeneously influence different groups of the population. In addition, the housing satisfaction, as an explanatory variable, is one of the most important determinants in people's overall life satisfaction.

Even though this chapter achieves some findings of the effects of housing conditions on individual subjective well-being; there might be more powerful factors related to housing satisfaction. However, due to the restriction of the CGSS survey, our model just contains limited indicators of housing-related features. With the development and improvement of the social survey, we can create more reliable estimates by including other typical housing variables in the model, such as the location of apartments, the neighbourhood's environment and so on. But clearly along with rising income, rising quality of housing accommodation is one way in which we can expect well-being to increase over time.

Chapter 6—Conclusion

6.1 Main Empirical Findings

Against the background of the prosperous development of China's economy, the Chinese housing market has become one of the most popular areas to be studied by many Chinese and foreign academics in recent times. This thesis discusses several important issues on the Chinese housing market, such as the determinants of house prices, convergence and ripple effects of regional house prices, and the relationship between housing conditions and individual subjective well-being.

After introducing the development of the Chinese housing market and summarising the existing literature, the first empirical chapter employs two dynamic panel data models—one-step system GMM estimation and two-step system GMM estimation—to estimate the effective factors that affect house prices in China by using a sample of 30 provinces/cities through 1999 to 2009. Some prevailing factors have been included, such as disposable income, urban population, unemployment rate, statutary reseve ratio, consumption factors, housing demand-supply factors, construction costs, land factors and investment factors. Meanwhile, in order to increase the effectiveness of our estimations, improvements have been made in the way these explanatory variables are included in the analysis. Moreover, the robustness checks verify our findings by using different explanatory variables or different estimation approaches, such as FE or RE.

The autocorrelation test (Arellano-Bond test) and overidentification test (Hansen test) imply our regressions are efficient to a great extent, because there is no evidence of autocorrelation and all instruments are jointly valid. The dynamic models with the lagged house prices indicate that the lagged house price significantly impacts on current house prices. Also, redefined independent variables, which have not been widely used before in this type of study, such as per capita disposable income of urban households, statutory reserve ratio, excessive housing demand this year, urban land use tax, and investment actually completed by enterprises for real estate development this year, have prominent explanatory power regarding the fluctuations in Chinese real estate prices, where their effects are more important in the long run than in the short run. However, Chinese house prices cannot be significantly explained solely by the urban population proportion, urban unemployment rate, construction costs and the housing consumption of urban households.

By using the house price index for 35 cities from 1998Q1 to 2010Q4, the second empirical chapter studies the convergence and ripple effects of regional house prices in China, through univariate/panel unit root tests (Levin *et al.*, Im *et al.*, ADF, PP, and Hadri tests), σ-/β-convergence analysis, panel regression models, cointegration tests and Granger causality tests. One of the innovations in this chapter is to revise the original link index for house prices into a continual index, which makes our estimations more valid and efficient.

By adopting the modified house price indexes, the results of both univariate and panel unit root tests suggest that there is non-convergence of regional house prices. However, by defining different 'clubs' within cities, panel unit root tests illustrate a limited convergence for some cities, such as Beijing, Shanghai, Shenzhen, Urumchi and Yinchuan. As for the alternative approaches, both the σ-convergence test and the β-convergence test imply the non-convergence of regional house prices as well. But, for the sub-sample of variation starting from 2004Q1, the panel regression suggests there is strong evidence of the β-convergence between regional house prices.

Although there is no significant evidence of convergence, some cities' house prices can 'ripple out' to others'. As well as this, the pairwise Engle-Granger cointegration tests suggest that there is a long-run cointegration relationship between a few specific cities, such as two-way cointegration between Dalian and Fuzhou, Hohhot and Taiyuan, Changchun and Guiyang, Changchun and Urumchi, Nanchang and Qingdao, Shenzhen and Zhengzhou, Hohhot and Jinan. In addition, the results of the Johansen system cointegration test for multivariate series indicate house prices in most cities have a long-run equilibrium relationship with the core cities—Beijing, Shanghai and Guangzhou.

The panel regression estimation verifies the primary indication of the Johansen system cointegration test, that show house price shocks in Beijing, Shanghai and Guangzhou affect other cities' house price changes in both the short-run and the long-run . Also, the previous house price changes significantly influence the current house prices negatively in the short run (in terms of quarter) and positively in the long run (in terms of year). The quarterly change may be more influenced by random stochastic factors than the annual figure, which will be dominated perhaps more by the underlying trend. This suggests that the stochastic factors are corrected for, whilst the long term factors have a continuing impact.

Additionally, the panel regressions show that, the distance factors from Shanghai and

Guangzhou significantly impact house price changes in other cities in the short run, but this effect becomes less significant in the long run, which with a diffusion model is exactly as one would expect. More interestingly, the house price changes in Beijing have a positive effect on other cities' house prices in the short term but a negative effect in the long run. One explanation is that the effect of Beijing's house price change is felt more quickly than other core cities and not diluted by distance. Therefore when year lagged effects are considered in order to reflect their own prices, the house prices of Beijing perform the role of a correction factor. The pairwise Granger causality tests investigate the short-run relationship of house price changes between each of two cities and finds complementary evidence of the significant impact of house price fluctuations in Beijing and Shenzhen; however, the panel regression models indicate their influence has weakened over time.

Overall, the empirical findings imply non-convergence between Chinese regional house prices during this period. However, there is evidence of ripple effects of some core cities in three major economic zones, especially in the short run. House price shocks in some core cities have ripple effects on other cities' house price changes, wherein Beijing, Shanghai, Hangzhou, Guangzhou and Shenzhen are the original regions of nationwide house price swings.

In order to investigate how the residential environment and housing conditions affect people's housing satisfaction and overall happiness, the third empirical chapter uses the 2006 CGSS survey data in urban China and the ordered probit model. The empirical results of the full sample indicate that both householder features and housing conditions have significant effects on people's housing satisfaction but less impact on people's overall happiness. But, when housing satisfaction is included as one of the explanatory variables in the overall happiness regression, it greatly impacts the overall happiness. Householder income and homeownership always play an important role in both housing satisfaction and overall happiness. Meanwhile, the results of the robustness checks have coincided with the above findings, by dropping highly correlated variables or transforming ordered dependent variable to 0-1 binary variable.

Through dividing the respondents into different groups, the housing factors have different effects on different population's subjective well-being. The Chow tests justify that both age and income divisions are significant for three models, especially for the overall happiness. But, the dummy variables for the separate and interactive effects of age groups and income groups indicate that, their effects are not always significant in the estimations. More specifically, the housing conditions are less important for the young than for the elderly, but old people care about all aspects of housing conditions. In respect to income groups, housing variables affect lower-income householders more significantly than higher-income ones. Only homeownership, house size and having bathrooms significantly affect rich people's housing satisfaction; comparatively, poor people's housing satisfaction are impacted by homeownership, house size, number of bedrooms, having bathrooms and housing type as well.

In addition, the Ramsey RESET test is used to generate the predicted value of housing satisfaction for the estimation of overall happiness. That rescues any misspecification problem of our estimations, to some extent. And the new regression presents similar findings with the original one, and suggests the effects of homeownership and housing conditions may be captured by the predicted housing satisfaction.

Moreover, the money equivalent analysis of house size implies that one more m^2 of house size can cause the same increase of life satisfaction as an 87.07, 87.44 and 56.15 yuan increase of annual income for the full sample, old people and low-income people samples respectively, whose average annual income are 14204, 11706 and 6175 yuan respectively. This suggests the poorer the people are, the easier it is to increase people's satisfaction with overall life by the provision of extra income and housing quality.

To sum up, the determinants of Chinese house prices are mainly dominated by the government policies and the speculative demand rather than the urbanization process and demographic factors. Secondly, although there is very limited evidence of convergence between regional house prices in China, however house prices in some core cities have ripple effects on other cities'. Finally, housing conditions significantly affect individual's subjective well-being, but they impact on different groups of the population in different ways.

6.2 Implications

In accordance with the empirical evidence, house prices in urban China are significantly influenced by government policies, such as monetary policy and land policy, but not affected by the urbanization process and demographic elements. Because the statutory reserve ratio and urban land use tax denoting government policies, play important roles in house prices;

however, the urban population proportion and the unemployment rate denoting the urbanization process and demographic elements, are not significantly related to house prices. That is consistent with the non-fully market-oriented status quo of the Chinese housing market. Also, the important roles of excessive housing demand and real estate investment on the real estate prices indicate that, the vigorous boom of the Chinese housing market has benefited from the lack of other efficient investment channels and the speculative demand of individuals and institutions. Thus, administrating and regulating house prices through the policy instruments is feasible and effective for the central and local authorities.

The fact that we have ripple effects but not convergence may imply that the effect from one city to another exists, but is not in itself enough to ensure convergence. For the record, we need to note that this is an extraordinary period of economic growth in China over this time period, and when growth stabilises in the future we may see the convergence of house prices. To a great extent, the non-convergence of regional house prices can be explained by the recent inequality in China. The current social situation reveals that the housing inequity for householders with different incomes has already been one of major problems in Chinese housing market.

Therein, the divergence evidence of Chinese house prices over 1997 and 2003 is most probably due to the extraordinary growth of the real estate market during this period. Because the State Council announced the final termination of the housing allocation system in 1998; the salient development of China's housing market initiates the divergence of house prices in this period. However, the relatively smooth development has aroused the apparent convergence of house prices within cities since 2004. That is most likely because the new 'bidding-auction-listing' land transferring system has been finally established in this year. Since then, the land using right has been marketized, and land use cost has become the major cost for real estate developers. The rapid economic growth of three big economic zones has contributed to the ripple effects of house prices in some core cities, such as Beijing in BTT-EC, Shanghai and Hangzhou in YRD-EC, Guangzhou and Shenzhen in PRD-EC. Their advanced economic status is the most important reason for their profound influence on other cities' housing markets.

The econometric analysis of the 2006 CGSS survey supports the theory that the living conditions and housing features have played important roles in individual's subjective well-being in urban areas, especially housing satisfaction and overall happiness. In China, people value their life by the four most essential necessities—‘*Yi Shi Zhu Xing*’, which refers to clothing, food, housing and transportation respectively. The importance of homeownership and housing conditions on people’s housing satisfaction and overall life satisfaction corroborates the traditional culture of ‘land is wealth’ in Chinese people’s belief. Therefore, improving people’s living conditions and housing facilities has great significance for the overall life satisfaction and happiness in China. However, the analysis has revealed substantial differences in the impact of houses, and housing characteristics, on different individuals according to their age and income. With respect to the former, policy makers should be aware that certain characteristics become more important as people age. This tentatively suggests that it may be optimal for people to move houses during the course of their adult life.

6.3 Further Research

In conclusion, this thesis has achieved a number of important conclusions about the Chinese housing market, and has given a series of constructive implications and suggestions as well. However, there are still many unexploited topics worthy to be studied about the Chinese housing market. For instance, the subsequent study on the determinants of house prices can focus on the distinguishing effects of these factors between the different regions. Since the market-oriented housing system has been truly established only after 1998, the dataset we used are too limited to separate them. As time goes on, as we get larger datasets, it will be interesting to divide the regions/provinces of China into different groups by geographical basis or economic basis. That will be able to reveal how the different determinants affect the house prices in different regions.

By using the modified house price indexes, this thesis suggests that a certain degree of convergence has appeared since 2004 and house prices in several core cities ripple out to other cities in China. However, a number of alternative approaches, such as SURADF (Seemingly Unrelated Regression Augmented Dickey-Fuller) test and ‘half-life’ analysis, are relevant in the field of convergence study, which have not yet been applied into the Chinese cases. Besides, the current work about the convergence between Chinese regional house prices, including the existing literature and this thesis, employs the house price indexes rather than the real house prices. The same methodologies we used would possibly display some different findings by applying the real prices.

Even though this thesis shows the effects of housing conditions on individual subjective well-being; there might be more powerful indicators related to housing satisfaction. Due to the restriction of the survey, only limited factors of housing-related features are contained in our model. With the development and improvement of the social survey, further estimates can be calculated by including other typical housing variables, such as the location of apartments, the neighbourhood's environment and so on. In addition, to remedy the endogeneity problem, the more advanced IV (instrument variable) techniques, developed by Chesher (2010) and Chesher & Smolinski (2012), can be employed for the ordered probit model in future research. But clearly along with rising income, the rising quality of housing accommodation is one way in which we can expect well-being to increase over time.

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